





MANUALS OF TECHNOLOGY.

Edited by Professor AYRTON, F.R.S., and RICHARD
WORMELL, D.Sc., M.A.

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EDITED BY

PROF. AYRTON, F.R.S., and R. WORMELL, D.Sc., M.A.



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DESIGN
IN
TEXTILE FABRICS

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WITH 10 COLOURED PLATES AND 106 DIAGRAMS

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P R E F A C E.



IN this manual an attempt has been made to place before the reader, as briefly and completely as possible, the principles of design in textile fabrics in its broadest sense, and to deal with the subject in such a manner as to combine with the question of decoration that of the proper structure of the cloth.

The practice of paying little or no attention to the proper structure of the fabric, and its suitability for the purposes to which it is to be applied in the arrangement of designs, is unfortunately far too common, and is the cause of a considerable waste of labour and expense in our manufacturing concerns. This may, perhaps, be to some extent due to the method of training those who are to be the designers, and also, to an even greater extent, to the fact that there has hitherto been no systematic treatment of the question. Most men engaged in the manufacture of textile fabrics have confined their attention to one branch, or to one class of goods, and have become proficient from practice only in that class. Their success has been entirely dependent upon the amount of attention they have paid to the particular class of fabrics they were engaged in manufacturing, or to the accuracy of their observations, and not to any—or, at the most, only to a slight—degree upon any systematic method or basis for their work. In the textile trades, as in every other, the

“rule of thumb,” or guess-work, must rapidly disappear, and be replaced by system. Fabrics must be made, as other articles are, with a proper regard to ornament, utility, and economy; the designer must consider both the end and the means, and nothing but this will secure success to him.

The rapid disappearance of the old apprentice system, the growth of large establishments, and the consequent subdivision of labour, accompanied by the ever-increasing demand for fabrics of a more artistic character to be applied to useful purposes, make it imperative upon the would-be designer or manufacturer to understand more fully than he has done in the past the principles upon which fabrics should be constructed, so as to fulfil all the necessary conditions. He must work on sound principles and leave nothing to chance.

The reader must not expect to go through this work in a hurried manner, or to thoroughly grasp all the details of the subject without further effort. Within the compass of this volume it is, of course, impossible to enter into all the particulars which would make the student at once perfectly conversant with the whole; but an effort has been made to lay down the leading principles clearly and completely, and to guide the student generally, rather than to enter too closely into minor details, which can only be sufficiently mastered by actual practice in the mill or workshop.

T. R. A.

Bradford.

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DESIGN IN TEXTILE FABRICS.

CHAPTER I.

TEXTILE FABRICS AND THEIR USES.

1. **The Objects to be kept in View in designing Textile Fabrics.**—The first objects we must set before us in designing textile fabrics are the uses to which they are to be applied, and the purposes they are intended to serve. Exactly in the same manner, if we are designing a bridge, a house, a mill, or a machine, our first concern must be to secure all the conditions of strength, convenience of arrangement, and other requisites, which will make it most suitable for the purposes to which it will be put. This having been done, we may then proceed to ornament the structure as we please, always taking care that the ornamentation does not in any way detract from the conditions of strength and general utility which have been our first and foremost aim. It thus follows that, in speaking of designing textile fabrics, we do not necessarily mean the application of art principles to their decoration, but we use the phrase in a more comprehensive sense, not only in reference to the decoration or ornamentation of the fabric, but also to its structure. If that is so, we must have what is commonly termed a theoretical basis upon which to build our fabric, and it may be as well to inquire, before going further—What is this theoretical basis? or

2. **What is the theory of the structure of fabrics?**
—A theory may be described as a supposition with

regard to cause and effect—or the connection and sequence of phenomena—which embraces all the circumstances known to attend their occurrence. A theory is tested by trial and observation. It must be founded upon actual knowledge of things—of the end to be attained, and the means which have been employed, not only by ourselves but by others, to attain the object at which we are aiming, or a similar object.

Upon this basis, then, we may at once proceed to examine into the theory of the manufacture of cloth, or “Design in Textile Fabrics.” Before we can enter into the question of the structure of fabrics, or deal with the materials from which they are made, we must determine what are the purposes they are intended to serve, and the qualities or properties they must possess to ensure those purposes being served in the best possible manner. It may, in the first place, be said that one of the chief uses of textile fabrics is as a covering for the body, to keep it warm, or to protect it from the inclemency of the weather ; or it may be that the covering is merely ornamental, and need not be of such close texture as that which the needs just referred to demand. Again, whether the covering be of the purely useful or of the purely ornamental character, yet, in all probability, in each case it will have to fulfil one condition of usefulness—namely, wear. This means that its structure must be such as will enable it to bear some strain, and in many cases also to resist a considerable amount of friction without damage.

In addition to the fabrics of a purely useful or purely ornamental character, we may in many cases be called upon to produce fabrics where both qualities are requisite. As the artistic taste of the people improves, they are not contented with the purely useful ; articles of utility must also be made more or less beautiful. We must ornament wherever we can, but in introducing the ornament we must be careful that we do not do it at the cost of utility.

We may, then, say that in these considerations of

utility or ornament we have the groundwork or basis of our theory. We have the knowledge of what we require, but that is only the first step. Before our theory can be complete we must consider how these fabrics are to be constructed, the materials from which they are to be made, and also, to some extent, the mechanical operations involved in their formation; and, being guided by a knowledge of what others have done before us, we must, as far as we can, determine the best and most economical methods of obtaining given results.

Textile fabrics may be generally described as a combination of filaments or threads, interlaced with each other in such a manner as to form a texture; and it is for us to ascertain what is the best method of interlacing those threads, so as to produce the fabric most adapted to our requirements.

In all cases where utility is to be the first consideration, the warp and weft threads which form the fabric must be so interlaced as to produce all the firmness possible, not only so as to be able to bear the greatest amount of strain, but also to be able to resist friction. In many instances we must also combine with these qualities bulk, or thickness of fabric; consequently, our fabric must be constructed so as to allow of the requisite amount of material being introduced into it.

Before going any further into the subject, we will see how fabrics are constructed, and what is the meaning of "warp and weft." In Fig. 1 we have a plan of what is known as a plain cloth. It

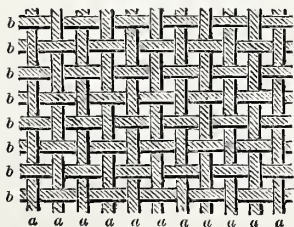


Fig. 1.

will be seen that there are two sets of threads, which cross each other at right angles, and interweave alternately. The threads marked *a*, or the longitudinal threads—or those running in the direction of the length

of the piece, and which are usually shown on paper in a vertical position, are what are termed the warp threads, and the transverse threads, *b*, are termed the weft threads. In all woven fabrics we have these two sets of threads to deal with, and the relation which one bears to the other, as well as the order of interweaving for the purpose of forming patterns, *constitute the design of the fabric*.

In the plain cloth plan in Fig. 1, it will be seen that, although we produce a very firm texture by the manner in which the two sets of threads interweave, yet we cannot possibly produce a very close texture. Certainly the fabric will be strong, each thread supporting the other to the utmost, yet it cannot be made sufficiently compact, either to produce a heavy fabric or a fabric which will retain heat, or keep the body warm to the fullest extent. By the very manner in which the threads intersect each other, they are prevented from lying perfectly close together; consequently, the fabric must be, in a greater or less degree, perforated.

3. The Effect of the Yarn upon the Fabric.—The perforations in a plain cloth will vary greatly under certain conditions: for instance, the thicker the threads from which the fabrics are made, the larger will be the perforations, and the thinner the threads, the smaller the perforations. Of course, in such cases the perforations will bear exactly the same ratio to the diameter of the thread if the relation of warp to weft be the same, but cloth made from fine yarns will possess the useful properties in a much greater degree in proportion to its weight than that made from thick threads. Other considerations will also affect the usefulness of the fabric. If we desire to produce a fabric of close texture—one which will have the perforations reduced to the smallest possible dimensions and retain the warmth of the body in the highest extent—we must use a yarn in which the fibres of which it is composed are laid as loosely together as possible. We can then, in the mechanical operations of weaving,

bring those threads closely together, and the looseness of the fibres will permit of their spreading out, and so of reducing the interstices to the lowest point.

On the other hand, if the threads are twisted very hard—that is, if the threads are made solid and compact—they will resist compression in the operation of weaving, and, the fibres being held firmly together in the thread, there is nothing left to spread out and cover the interstices; consequently, we shall have an open fabric, but the fibres being firmly interlocked in the thread, we shall have a fabric which will bear more strain, and will offer also more resistance to friction, than in the other case. We must, therefore, obtain one quality in this fabric at the cost of some other.

4.—The Effect of the Twist of the Yarn.—Another matter which materially affects the closeness of texture in a plain cloth is the direction of the twist of the weft in relation to that of the warp. On reference to Fig. 1 it will be seen that the two sets of threads when placed together in the fabric have the twist running in the same direction; that being so, the fibres—or, if we may so term them, the strands—of the two sets of threads will become embedded into each other, and so make a close and compact fabric. If, on the other hand, the twist of the weft be contrary to that of the warp when the two are placed together, as shown in Fig. 2, the threads cannot become so intimately connected, and, consequently, the fabric cannot be so close and free from perforations.

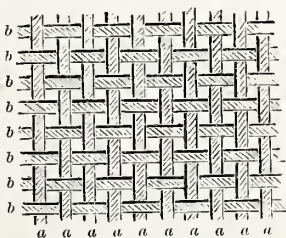


Fig. 2.

To give an illustration on a large scale. If we take two thick cords or ropes, and lay them together at right angles to each other, with the twist of both in the same direction, we shall find that the thick strands of one

rope will fall into the hollows between the strands of the other, and so the two will occupy the smallest possible space ; but if the strands are in opposite directions, instead of their falling between each other, and one strand filling the hollow in the other, their ridges will come together, and there will be an opening equal to the hollows between the strands of *both* ropes. We have, therefore, increased openness in the structure of the fabric without a corresponding gain in any direction.

5. Relations of Warp and Weft, and their Effect upon the Fabric.—Up to this point we have been dealing only with what may be called a *true* plain fabric, or a fabric in which the weft and warp are equal, or nearly so, in their diameters and in the number of ends per inch each way ; but we may produce fabrics in which the relations of weft to warp are quite altered, and we may do this for two purposes—either for obtaining increased strength, warmth, and weight, or for ornamentation.

Suppose we take the class of fabrics commonly known as poplins, and which present a corded or ribbed appearance, the ribs running across the fabric in the direction of the weft ; in such fabrics there is a great preponderance of warp over weft, more especially as regards the number of threads per inch. But for the production of fabrics of the best type the warp threads are much thinner than those of the weft. In fact, although the interweaving of weft with warp is precisely the same as in the plain cloths with which we have been dealing, the alteration in the relative quantities and thickness of weft and warp completely changes the texture and appearance of the fabric. A plain cloth, in which warp and weft are equal, will present an appearance of waviness in both warp and weft on the fabric being dissected ; but a fabric in which the warp threads predominate largely over the weft, so far as ends per inch go, and in which, consequently, the warp threads are proportionately thinner, would present the weft as a straight line, and

the warp bending round it. A plan of this fabric is shown in Fig. 3, and a section in Fig. 4.

In the plan it will be seen that the weft threads are much thicker than the warp threads, and also that the latter are placed closely together.

In some fabrics of this type these are placed so closely that they are actually compressed, and made to occupy a space less than their true diameter. It will also be seen that the weft threads are some distance apart. It only

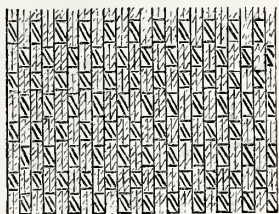


Fig. 3.

requires a careful examination of the structure of the fabric to ascertain the cause of this, as also its effect upon the appearance, as well as upon the usefulness of the cloth.



Fig. 4.

The warp threads are placed close together, and cross between each weft thread, or *pick*, as it is technically termed. The warp is also much thinner than the weft; as a consequence, no matter how much tension may be put upon the warp, either in the process of weaving or after the fabric is formed, it cannot bend the weft out of its straight line, simply because the intervals of space between the warp threads are so small, as compared with the thickness of the weft, that the weft cannot be bent into them either from above or below; or, in other words, the closeness of the warp threads forms a continuous bed upon which the weft is laid. Then, with regard to the distance apart of the weft threads, or picks, the warp crossing between them prevents them from coming close together; each pick being separated from the other in this manner produces the ribbed-like effect peculiar to this class of fabric. It will be evident from the structure of the fabric, the closeness

of the warp threads, and the strength of the weft that this class of cloth is well calculated both to resist wear and retain warmth, and there is, probably, no kind of fabric which, for the weight of material employed, can compare with it in these respects.

Another class of fabric of a very similar character is largely employed for decorative purposes, and to some extent also for articles of dress—namely, the cloth com-



Fig. 5.

monly known as "repp." Its structure is different from that of either of the two plain cloths of which we have been speaking, though possessing one of the chief characteristics of the poplin, or gros-grain, type, inasmuch as the warp is made to bend round the weft, and the weft is laid in perfectly straight lines. In Fig. 5 we have a section of what is considered the best type of this class.

Here it will be seen that in both the warp and the weft there is a thick and a thin thread alternately, and in the operation of weaving the thin thread in the warp is held very tightly, while the thick thread is held very loosely. Again, the thin weft is always between the warp threads on *the same side* of the thin thread, and the thick weft passes always on the *contrary side* of the same thread; the result is that the thick warp—which usually consists of several threads put together—in consequence of the slight tension upon it, is made to bend round the weft threads, and the thin warp is held quite or nearly straight, thus producing the clearly-defined rib, very prominent on that side of the fabric where the thick weft is, and less so on the other side.

Again, another class of plain fabric is obtained by a reversal of the conditions which produce the poplin—that is, the warp threads are thick and the weft thin. The warp is held in straight lines, and the weft made to bend round it. The plan shown in Fig. 3 may be taken

as a plan of this class of cloth, as well as the plan of a poplin cloth, only that the thick straight threads must be taken as warp, and the thin bent threads as weft. The section Fig. 4 would also be a section of this cloth, but would be a transverse section, the circles showing the end of the warp threads and the bent threads being the weft. This class, commonly known as cords, is usually made with two or more warp threads run together to produce the requisite bulk, instead of using one thick thread.

In the production of the four classes of plain fabrics mentioned, great care should be exercised in proportioning the warp to the weft, but more especially with reference to the poplin and cord. In what we have spoken of as the true plain cloth we have assumed that warp and weft are equal in quantity, and in that case both warp and weft would be slightly bent out of the straight line; each would exert an equal power over the other. That being so, if friction be applied to the cloth, each set of threads would hold the other firmly in its place, and no matter whether the friction be applied in the direction of the warp or weft, the result would be the same—each would possess the same power of resistance. In the other classes it would not be so. If we take the poplin type, where we have the weft laid straight and the warp bent round it, any friction in the direction of the warp threads could have little or no effect; but friction in the direction of the weft would have the effect of displacing the warp, because there is nothing to keep them in place except their pressure one against another; they are bent round a straight body more or less smooth, and have no support except their own pressure. Thus, unless they are sufficiently close together to give each other sufficient support, the cloth cannot be serviceable as an article of dress, or for any other purpose where it will have to resist friction. The same remark will apply also to the “répp” and “cord” classes, but in the latter the dis-

placement will be in the weft threads by friction in the direction of the warp.

In all four classes of plain cloth we could only vary the weight of cloth by altering the size of thread ; and our means of ornamentation are also limited. We can only alter the size of cord or rib by the use of different sizes of threads ; but we can ornament the fabric by the introduction of colour, and that colour we may use in the warp only, in the weft alone, or in both warp and weft. So far as the use of colour goes in ornamenting plain cloths, we have a wide field ; but that is a subject we must consider in another chapter. We must first deal with the structure of fabrics, and their ornamentation by the variation in the interweaving of the threads which compose the fabric.

6. Twilled Fabrics.—We must now discuss the structure of other than plain fabrics, and ascertain what is the use or value of other methods or systems of constructing cloths.

The class of fabrics which comes nearest to plain cloth is that known as twills or twilled fabrics ; and in their production we may have two objects in view—first, increase of bulk or thickness of fabric ; and second, ornamentation. The first and chief difference between the structure of this class of cloth and plain cloth is that in the latter the warp and weft interweave alternately, whereas in twilled fabrics they interweave at such intervals as may be required for the formation of the pattern. Again, what is termed the complete pattern in plain cloth is represented by two ends of warp and two picks of weft, while in twilled cloth a greater number of ends and picks are required to complete the pattern ; or, in other words, in all plain cloths, every alternate end is a repetition ; the same holds of the picks, but in twilled cloths the repetition will occur at longer intervals. Fig. 6 is the plan of a twill of a very common order, and one regularly in use in fabrics made from all kinds of materials.

In this it will be seen that each warp thread passes alternately over and under two weft threads or picks, and in like manner each weft thread passes alternately under and over two warp threads. But each end does not pass under and over the same two picks, nor does each pick pass under or over the same two ends, nor are they alternate in their action, as are the ends and picks of plain cloth; but they change in regular consecutive order; that is, if the first end passes over numbers one and two

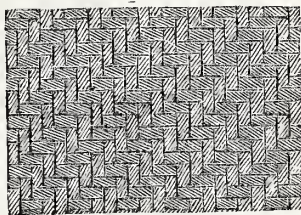


Fig. 6.

picks, the second end passes over numbers two and three picks, and so on, each end advancing one pick before it rises to the surface, or passes to the back, and each pick advancing one end in the same manner. This order of changing of the ends and picks will have the effect of producing a distinct pattern upon the fabric, a species of cord running in a diagonal direction across it. But another matter of much more importance than the mere pattern is the fact that this order of working permits us to introduce more material into the fabric, and so make it more bulky and closer in its structure. The reason for this is to be found in the simple fact that the weft and warp interweaving only at intervals of two ends or picks permit the two threads both of warp and weft to lie closely together, and consequently to allow of a greater number per inch to be introduced into the fabric than can be done in plain cloths.

True, as we have shown, we may make plain cloths in which the warp threads lie perfectly close together, and others in which the weft threads lie perfectly close together; but in the one case the weft threads are a considerable distance apart, and in the other the warp threads

are a considerable distance apart, whereas in the twill cloth the weft and warp both lie equally close together, so that we obtain the requisite closeness of texture in both directions, and a corresponding increase in the bulk of the fabric. Along with this closeness of texture, and increased weight or bulk, we also obtain another advantage over the plain cloth, namely, that by the order of interweaving the warp bends round the weft, and the weft round the warp in an equal degree, exactly as in the first order of plain cloth. So that if the number of threads per inch each way is properly proportioned to their diameters, and to the order of interweaving, the fabric will possess the power to resist friction, not merely in the same degree as the plain cloth of the first order, but in a greater degree proportionate to the increased quantity of material it contains.

7.—Alteration of Twill to increase Bulk.—We also possess the power of increasing the bulk in a great degree by altering the twill so as to interweave the two sets of threads at greater intervals, and just as we increase the intervals we increase the number of threads which may be contained in a given space. Of course along with this a limit of increased usefulness will be reached. We say that we increase the powers of resisting friction by the increased material employed in the construction of the fabric, but if our intervals of interweaving are too great, the two sets of threads will to some extent lose their power of supporting each other; we shall have too great a length of loose yarn presented on the surface. This yarn being composed of fibres, each individual fibre is presented for a considerable portion of its length to the wearing surface; and if friction be applied, it may be too readily drawn away from its fellows, and so by degrees the thread, and ultimately the fabric, becomes weakened. Again, no doubt the looseness of the interweaving will reduce the power of the fabric to bear a strain; although a loosely interwoven cloth—if the quantity of yarn be properly

proportioned to the order of interweaving—will still be the stronger so far as tensile strength is concerned, than one more closely interwoven, yet it will not be so strong in proportion to the quantity of material of which it is composed; and if the number of threads in a given space, or the diameter of the threads, be not properly proportioned to the pattern, the fabric will be positively weaker.

8. Alteration of Twills to increase Strength.—Satin.—Quite apart from the question of ornamentation, there are certain orders of arrangement in twills which may be specially resorted to for the production of fabrics which are designed to bear an increased amount of friction or strain in one direction or another; and when we are arranging our patterns for the purpose of ornamentation, we must not forget the peculiar properties which attach themselves to patterns of given classes.

If we take one class as typical, in order to point out the peculiar arrangement and its effect upon the fabric, it may serve as a guide to us when dealing with patterns for ornamenting. This class is commonly known as satins or broken twills. The peculiarity of this sort of twills is that the order of interweaving the two sets of threads does not follow consecutively, but at intervals, especial care being taken that at no point do they follow consecutively. An example of the simplest kind, and one most commonly employed, is shown in Fig. 7.

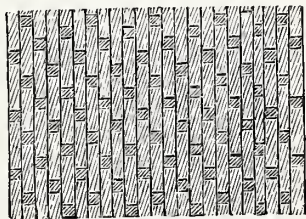


Fig. 7.

In this plan it will be observed that the order of interweaving is at every fifth end or pick, and that the two succeeding picks do not interweave with adjoining ends, but at intervals of two; that is, if number one pick pass over the first end of warp, number two will

pass over the third end, and so on. Now suppose that we wish the fabric to be able to bear a great strain in the direction of the warp, it will be made with what is termed a warp surface. The warp threads will be placed as closely together as possible; certainly they should be placed as close to each other as their diameters will permit; and as the weft is inserted, one end will be withdrawn from the surface of the fabric, and will bend round the weft at the back. As the next pick is inserted, another end will be withdrawn, the first one returning to its original place, but as the ends are not withdrawn in consecutive order, the weft is not made to bend round the warp in any degree, but remains perfectly straight, the warp only being drawn out of its course. That being so, the weft threads cannot be laid close together, but will always be separated from each other by at least the diameter of the warp thread; therefore we shall always have a greater number of warp threads per inch than of weft threads. Again, if it be desired to produce on the fabric a smooth, unbroken surface, with no pattern visible, the warp threads may be placed so closely together that as one is withdrawn to bend round the weft, those on each side of it will close over the vacancy and completely hide the point where it has interwoven with the weft. In that case the number of warp threads would be increased in proportion to the number of weft, and consequently the fabric will be capable of bearing an increased strain upon the warp, or in the direction of the length of the piece, but a decreased strain in the direction of its width, or of the weft.

Exactly the same principle will apply to fabrics where a weft surface is produced. The warp threads are set such a distance apart as will permit of the weft threads passing readily between them, and bending round them. The weft threads are inserted as closely as their diameters will allow, and in some cases so as to pass over and hide the point where weft has bent around warp; and, again, in many cases so closely that the weft is compressed, and

loses its true cylindrical form. In such fabrics the greatest strength is in the direction of the weft, just in the proportion to the quantity of material employed.

9. Satins used for Ornamental Purposes.—This principle of interweaving is sometimes employed where the object is purely ornamental, as in the satins used so largely for trimmings and for ladies' dress goods. In such cases the first object is to produce a highly lustrous surface, perfectly smooth, showing no pattern. Then if the fabric is intended to serve an useful purpose, as well as to bear strain, we must take care that the material which is present in least quantity, whether it be weft or warp, shall be of sufficient strength to compensate for the absence of quantity; otherwise the fabric will be able to bear strain in one direction only, whereas by proper attention to the strength of the material employed we may make it able to bear the requisite strain in both directions.

Although this class of satins is a large one in itself, yet we are only considering it here as representing a type of structure which may be, and is, used very commonly in conjunction with patterns for ornamentation. These we shall have to consider more fully in a subsequent chapter.

10. Double Cloths.—We next come to the consideration of a different class of fabric, not necessarily different in the principle upon which the fabric is constructed, but in regard to its use and ornamentation.

It frequently happens that in producing fabrics intended to serve special purposes, we cannot obtain the requisite weight and bulk of fabric without producing at the same time coarseness and openness of structure. If we wish to produce a heavy fabric, we have only two possible means of doing it—either the use of thick bulky threads, or an increased number of fine ones. If we use thick bulky threads, our fabric must present an appearance of coarseness, no matter what may be the order of interweaving; and we have no possible means of

reducing the coarseness. If we use fine threads, it is more than likely that the order of interweaving will prevent the introduction of as many threads as will produce the weight of fabric we desire. Then we have no alternative but to resort to *double cloth*; that is, instead of trying to crowd into a given space of a single fabric a number of threads, which will necessitate an undue compression of each individual thread, and require an immense amount of power to do so, and at the same time injure, in a greater or less degree, the threads of either warp or weft, or both, we must make two fabrics, and bind them together in the process of weaving so as to make them really one. There are among double cloths, or what are commonly known as double cloths, certain classes which are not really double cloths, but, more correctly speaking, double-faced cloths, that is, there may be one warp and two wefts, or one weft and two warps. A true double cloth must be really two separate fabrics, each having its own warp and weft. The two fabrics are woven at the same time, certainly; they are more or less intermixed with each other, but they never lose their individuality, whether they are combined for the mere purpose of producing a fabric of a given weight, or for ornamentation, or for both combined. So as to obtain readily a clear conception of what is really meant by double cloths, we will first examine the double-faced cloths. If we turn to Fig. 7, we find in that a closely-set warp, interwoven with weft in such a manner that the weft is practically invisible on the surface of the fabric. Suppose we introduce another warp, and so interweave it with the same weft that the weft is contained between the two warps; we shall then have a fabric both sides of which present warp only, the weft which binds the two warps together being contained between them. This we can easily do by taking care to select the point of interweaving the weft with each warp in such a manner that the one warp does not interfere with the other, as shown in the section, Fig. 8.

We have here, then, a ready means of producing a fabric which will give increased weight and bulk, increased strength to bear strain in the direction of the



Fig. 8.*

warp, and a cloth which may be used as a reversible article. One side may be of one colour, and the other side of a different colour; or we may use it for the purpose of producing an article of dress, one side being a fine fabric and the other side a coarser one, to serve merely as a lining.

Then, exactly in the same manner as we may make the satin referred to in Fig. 7 to have either the warp or the weft predominating, we may have our double-faced cloth so as to present weft on both sides instead of warp on both sides. In that case we should simply reverse the conditions—the warp would be contained between the two wefts; the greatest strength will be in the direction of the weft. And in the same way we may make one side fine and another coarse; one side in either cloth may be highly ornamented, either with colour or in the order of interweaving the threads together, and the other



Fig. 9.*

side may be quite plain as regards colour, and nearly so as regards pattern. Fig. 9 would show a section of a fabric having two weft surfaces.

In the case of a double cloth, as has been said, we must employ two separate warps, and also two separate wefts, each weft interweaving with its own warp, and

* In this and other figures, the letters "wp." stand for "warp," and "wft." "weft."

consequently each fabric made quite separate and apart from the other. Not only may the fabrics be separate, but each may be of a different degree of fineness, made from a different material, and of a different pattern; then the two may be bound together so as to form one fabric.

In cases where we desire to produce a fabric of a given weight and degree of fineness, and the pattern or order of interweaving we desire to apply to the fabric will not enable us to introduce as much material as will produce the required weight, we may then resort to double cloths, because here we can combine any two fabrics, and so obtain a greater weight, along with fineness, than we can with a single cloth. Again, we may make one of the fabrics fine and the other coarse, and so produce the required weight at a less cost than in a single fabric of the same weight; and at the same time we may secure all the advantages of strength, power to resist friction, and to retain warmth as an article of clothing, in an even greater degree than in a single fabric of the same weight. In many cases cloths are made not only double, but three and even fourfold. Whenever double cloths are resorted to there is a distinct object in view—to produce weight alone, or at a small cost, to make a fine surface on a fabric of a given weight, to secure additional strength, warmth, and wearing powers, or sometimes for the purpose of ornamentation solely, by causing the cloths to exchange places and so form figures.

11. Gauze Cloths.—Another class of fabrics, and one which differs very materially from each of the others, is gauze. This belongs to the purely ornamental fabrics. Because of the manner in which it is constructed, it will not permit of a close or thick fabric being formed; in fact, it may be said to be of the lace type of fabrics. The threads do not merely interweave with each other, but they twist round each other in such a manner as to form an open perforated fabric. One

peculiarity of the structure is to give great strength for the quantity of material it contains; but from the fact of the threads twisting round each other, the quantity of material must be very limited. Although we cannot produce in this class of fabrics articles of use, so far as their power of retaining warmth is concerned, we have probably the widest field for ornamentation, because we can combine it with the other orders of working or interweaving, and so have at our command all the means of ornamentation which structure of cloth can give.

Thus far, we have dealt with the structure of cloth only, so that we might see upon what basis we must work for ornamentation. No matter to what purposes fabrics are to be applied, we must not in ornamenting them detract from their utility; and as the chief mode of ornamenting them is in the variations of the order of interweaving the threads of which they are composed, the structure of the fabric must be the first question to consider in applying our ornamentation to it.

12. Plush or Pile Fabrics.—We have not yet referred to ornamenting by the introduction of additional threads, these threads being arranged in such a manner as to form figures or patterns, or it may be to form what is termed pile or plush. By the use of such threads we have an unlimited field for ornamentation, without in any way detracting from the usefulness of the fabric, but in the great majority of cases really adding materially to its strength, and making it more useful.

We have now so far developed our theory as to have determined the common principle of structure of fabrics, and in a general way the qualities or properties each variety of structure must possess, so as to suit it for the purposes to which it is to be applied.

CHAPTER II.

THE STRUCTURE OF THREADS.

13. **Relation between Thread and Cloth.**—Immediately connected with the structure of the cloth, and really exerting considerable influence upon it, is the structure of the threads of which it is composed. Not only will this affect it so far as its usefulness goes, but it will also largely affect the power of ornamenting.

It may appear out of place in a work on Design in Textile Fabrics to enter into the question of the structure of threads and the fibres from which they are made; but as they affect in such a degree the structure of the cloth, we must deal with it before we can have a thorough comprehension of our power of varying that structure and ornamenting it.

14.—We may begin by asking, "*What is a thread?*" A thread is said to be "a filament composed of fibres twisted together or otherwise." Thus, before we enter into a detailed examination of the structure of the thread itself, we will examine very briefly the chief characteristics of the fibres from which it is made. The fibres most largely used in the manufacture of textile fabrics are wool, cotton, silk, and flax, and each possesses peculiar properties which give it a special and particular value.

15.—If we examine a lock of wool as it comes from the back of the sheep, the first thing which will attract our attention is a peculiar waviness or crimpiness in the lock. If we separate a single fibre from the rest, we shall find that it is waved in the same manner, and also that the waves are very regular throughout. If we carry our examination further, and place the fibre under

a microscope, we shall find the whole surface covered with scales, the scales forming a series of rings round the fibre, and all pointing from root to tip. We shall also find that the fibre is a hollow tube filled with a granulated liquid. It is the wave and scale of the wool which give it its peculiar value. In the preparation for spinning, the fibres are intermixed in such a manner that the directions of the scales are as much opposed to each other as possible; that is, the fibres are placed root to tip and tip to root. As they are spun, the scales of the opposing fibres engage with each other, and become interlocked, and the more the thread is spun the more firmly do they hold each other, and so make a strong thread; but the spinning property, or the readiness to form a thread, is not the only value of these scales. After the fabric is formed most woollen goods undergo a process of milling or felting; that is, the fibres are made to interlock with each other more firmly, and consequently the fabric becomes more close and compact. In this operation the waves or crimps of the fibre are valuable as well as the scales. To cause the felting to take place, the cloth is moistened with a strong solution, consisting largely of soap, and pressure is applied. The result is the fibres are straightened out; the scales of opposing fibres engage with each other. As the pressure is removed, the natural spring of the fibre asserts itself: it tries to return to its original wavy condition; in doing so the fibres are drawn more closely together. The pressure is again applied, and the operation repeated. By degrees the fibres become so closely intermixed that the threads lose their individuality, and the cloth becomes one compact solid mass. To assist this operation of felting, where it is required in a great degree, the thread must be specially constructed; and it will be very evident that when the cloth is operated upon in this manner, whatever pattern existed must be, in a great measure, lost.

Different classes and qualities of wool differ very

much in the degree in which they possess those waves and scales, and consequently in their value for the production of fabrics of given characters.

16.—Cotton, which is a vegetable fibre, presents a very different appearance from wool; it is really a thin, collapsed tube, and under the microscope appears like a ribbon more or less twisted. These twists in the fibre—which is of a very soft, pliable nature—are valuable as giving strength to the thread by their friction upon each other.

17.—Silk is a straight, smooth fibre, very highly polished, and when magnified, presents somewhat the appearance of a glass rod. It is very soft and pliable, and lends itself readily to the formation of a thread.

18.—Flax is a vegetable fibre and has an appearance something like long grass; it is cylindrical in form, and with knots at intervals, exactly as we often see it in canes or long grass.

Although we have here four classes of fibre, each is capable of being made into two distinct kinds of thread, and it is the formation of this thread which so materially affects the formation, or at least the ornamentation, of the fabric.

19. **Preparing and Spinning the Fibres into Yarn. Woollen Yarn.**—If we deal first with the preparation and spinning of wool, it will enable us to have a clearer conception of the preparation and spinning of the other fibres.

The first process after the wool has been washed to free it from its impurities, is the separation and straightening of the fibres, and this is equally necessary for the production of both classes of yarn made from wool, although the mode of dealing with long wool in the first operation is very different from that of dealing with short wools. In the separation and straightening of the fibres of the latter, a carding machine is employed. This machine consists of a series of cylinders covered with cards, or finely set teeth; these cylinders revolve in

different directions, and at different speeds. They are placed so near each other that as the wool is carried forward by one upon its teeth, it is caught by the teeth of the other, and so, by degrees, each fibre is separated from the other, but there is little or no attempt to secure the parallelism of the fibres; they are simply separated.

If the wool is intended for the production of what is termed a woollen thread, it is passed through two or three of these carding machines, according to the quality of yarn to be produced, and as it comes off the last machine it is condensed or reduced to thick rope-like threads, and from there it passes to the mule to be spun. It must be remembered that in passing through the carding machines, the chief object has been the separation of the fibres, without much regard to their parallelism. When the thread formed by the condenser is placed upon the mule it is passed through a pair of rollers, and thence to the spindle. This spindle is carried upon a carriage which alternately recedes from and advances towards the rollers through which the thread has been passed. Having attached the thread to the spindle with the carriage brought close up to the rollers, the carriage is made to recede, at the same time the spindles commence to revolve, and so twist the thread; the rollers also revolve and give off yarn. After the carriage has travelled a given distance the rollers stop, and consequently cease the delivery of yarn. The carriage still continues to recede, and consequently draws out, or attenuates, the thread. At the same time the spindles are continuing to revolve and twist the yarn, so that the process of attenuating or drawing out the thread and twisting go on at the same time. The result of this is that the longest fibres composing the thread, and those most nearly approaching parallelism form the core or centre of the thread, and the short fibres, and those which have not been laid parallel, become partly embedded in the thread, and partly project from it, so that the thread presents a rough appearance with fibres projecting from

it all round its circumference, and throughout its entire length.

20. Inequality of Woollen Thread.—Another feature of woollen threads is the inequality of thickness. In the preparation of the wool for spinning no means are provided, except in the feeding of the wool to the carding machines, to insure equality. And, again, in the actual process of spinning on the mule there is a tendency rather to increase than diminish the inequalities. As the twist is being put in the thread by the revolutions of the spindles, it will exercise more power over the thin than the thick portions of the thread, and so make it firmer, and consequently of less diameter than the portions over which it exercises less power.

If we take a thread and make a section of it at points representing the various thicknesses or diameters, the area of these sections will vary as the squares of their diameters, therefore the power of the twist over these portions will be in the direct ratio of the area of their sections. True, a certain amount of equalisation will take place as a result of this varying power of the twist, and of the operations of drawing and twisting occurring simultaneously. As the thin portions become firmly twisted they will naturally resist the drawing process, so that from the moment these thin places have become sufficiently firm to resist the drawing action, the attenuation will be confined to the thick portions, but the latter will not be reduced to the proportions of the thin parts, which all the time are receiving more and more twist, and as a consequence, although they retain all the fibres, or have none drawn from them, are still becoming thinner owing to the compression of the fibres by being more firmly twisted.

21. Advantage of Structure of Woollen Threads.—We may now see what advantages or disadvantages this type of thread possesses in the production of fabrics of given character. From its very unevenness, and what we may term roughness, from the projecting fibres upon

its surface, it is unfitted for the production of fabrics where pattern is to be formed by the interweaving of the threads, because the loose, fibrous character of the thread will tend to hide any pattern so produced, and, added to that, the inequalities in its diameter will tend to make the pattern appear very irregular. On the other hand, where the fabrics have to undergo the process of milling or felting, the loose, fibrous character of the thread is a great advantage, because the fibres of one thread can become readily interlocked with those of another and so assist to the utmost the process of felting. Again, there is a further tendency, in consequence of the threads losing their individuality, to lose or hide any pattern in the fabric; so that we may say that the loose, fibrous woollen thread is specially suitable for the manufacture of close, felted cloths, which will give fine texture, firm compactness of structure, great power of retaining warmth and of resisting strain or friction, but not the power of producing patterns by the interweaving of the threads.

22. Worsted Yarn.—We will now glance briefly at the structure of the second class of thread made from wool, or what is commonly known as worsted. It is usually supposed that the chief difference between woollen and worsted is that the former is made from short wool exclusively and the latter from long wool. In reality, large quantities of worsted are made from wool of exactly the same class and quality as woollen yarns. Certainly, much shorter wool can be spun into woollen than can be spun into worsted, but the difference in the length of wool does not constitute the difference in the two threads.

In preparing the wool for spinning into worsted yarns, the first process, as in that of woollen yarn, is the separation of the fibres, and, indeed, where short wools are employed, upon practically the same machine, but accompanying or immediately following the process of separation, the fibres are drawn parallel to each other.

The wool passes through several machines for the sole purpose of obtaining this parallelism; when that has been accomplished as far as possible the wool is "combed"—that is, the wool is passed to a machine which draws it through fine steel combs, which further ensures the parallelism of the fibres, and at the same time takes away all the short fibres which, owing to their shortness, are incapable of being straightened out, so that we have all our fibres laid straight and parallel, and at the same time all the very short fibres removed, and we retain for the yarn we are about to spin only the longest and straightest fibres. After the process of combing commences a process of equalisation and attenuation. The wool is drawn from the comb in a thick rope, or "sliver." A number of these slivers are put together, passed through a series of combs for the purpose of preserving, and, if necessary, increasing, the parallelism of the fibres, and drawn out to the thickness of one or less than one of the original slivers. This process of equalisation goes on until in many cases the last thread has been drawn out some millions of times, so that any inequalities in one of the original slivers has been neutralised by inequalities in other slivers. After the process of equalisation is complete, it undergoes a process of attenuation, or further drawing out, and is then passed to the spinning frame. Worsted yarns are usually spun upon the "throstle" frame. This machine is provided with a series of drawing rollers, which by their varying speed further reduce, or draw out, the thread before the operation of twisting commences; it is then twisted and wound upon the bobbin at the same time. But in this the spinning and drawing out do not take place simultaneously as in woollen, but successively; consequently, in whatever position the fibres have been laid in the drawing they will not be disturbed in the spinning, and as we have taken every precaution in the preparation of the yarn for spinning to ensure the parallelism of the fibres, they will still retain that

position. Further, the thread has been equalised as far as possible ; therefore, when spun, we may expect great regularity in its diameter.

23. Advantages of Structure of Worsted Threads.

—We have here, then, a thread of great regularity in its diameter, with all its fibres laid parallel and nearly of the same length. It will, therefore, possess great and tolerably uniform strength, and be specially suited for the formation of patterns in the fabric. It will not be suitable for milling or felting, because the fibres of one thread cannot combine with those of another thread, and thus they cannot lose their individuality ; consequently, although the fabric is strong in the individual threads which compose it, these threads cannot intermingle so freely as in woollen cloth. It cannot possess the power to resist strain and friction in the same degree and in the same way, because the threads retain their individuality, and the fabric not being so compact as a woollen cloth, it will not have the same power of retaining warmth. On the other hand, any pattern woven upon it will not be lost or hid in the process of finishing, so that each class of thread has its own peculiar properties and advantages.

24. Preparing and Spinning Cotton.—Cotton is prepared like woollen on the carding machines, but undergoes a process of equalisation like worsted ; sometimes, for the production of high-class yarns, it is combed. The spinning is done sometimes on the mule and sometimes on the throstle frame, so that the majority of cotton yarns may be said to partake of the character of both woollen and worsted so far as their structure is concerned. A combed yarn spun on a throstle frame would exactly answer in structure to the worsted thread. Of course, in yarns made from wool there are many which partake of the compound character.

25. Preparing and Spinning Flax.—Flax also gives us two classes of yarn—namely, linen or line yarn, and tow yarn. The processes of preparing linen yarn are very similar to

those of preparing worsted ; of course, the machines are different in their construction, because of the difference in the length and character of the fibre. Flax is "hackled"—beat or crushed—to make it flexible ; it is then "scutched," an operation equivalent to combing. In some cases the fibres are too long to work ; they are then broken by a "saw." After the scutching the short fibres are carded for "tow" yarn in the same manner as the "noil," or short fibres of wool after combing, are carded for woollen yarn.

26. Preparing Silk Yarns.—Silk is very different from any of the other fibres. Raw silk is drawn from the cocoon of the silk-worm in one long continuous filament ; several of these are put together, and produce what is known as "tram," or weft silk, and "organ-zine," or warp silk. The one is put together loosely, with little or no twist, and the other is twisted firmly together to make a solid, compact thread. Both have the same feature of being formed of long filaments, consequently they are suited for the production of patterns upon the fabric, and also possess great strength.

In some cases the cocoons are damaged, and incapable of being wound or drawn out in one continuous filament. Such cocoons are taken and torn up into lengths. They are then combed, the fibres laid parallel, and spun in the same manner as cotton or worsted. This yarn, of course, does not possess the freedom from fibres upon its surface which "raw" silk does ; yet, the fibres being combed out, and being of considerable length, it is a very strong thread, and well suited for the production of patterns upon the fabric.

We have now a tolerably clear conception of the first principles which must guide us in our application of ornament to fabrics. First, we have examined into the theory of the structure of cloth, and the suitability of the various kinds of structure for useful and ornamental purposes. We have then had a brief examination of the structure of threads, and the fibres from which they are

made, and the suitability of each for the different purposes to which it may be applied. Our next object must be to examine into the principle of ornamenting fabrics, either by the order of interweaving the threads together, the introduction of colour, or both. And throughout we must keep closely in view the purposes to which the fabrics are to be applied, the considerations of strength and general utility, and in no case must we impair the utility of the fabric by ornamentation, but rather combine the two to the utmost, and direct our attention always to the production of an article which shall not only be pleasing to the eye as a work of art, but also serve to the utmost all the objects for which it is designed.

CHAPTER III.

ORNAMENTATION OF FABRICS IN THEIR STRUCTURE.

27. *Relation of Ornament to Structure.*—Our next duty is to consider the ornamentation of the fabric, and in doing so we must take care that we do nothing which will detract from its usefulness. We may, of course, ornament with colour to any extent without in any way adding to or detracting from the utility of the fabric so far as its wearing properties, strength, &c., are concerned. But the question of the use of colour we may deal with separately; our present concern must be to ornament by the varying order of interweaving of the threads or constructing the fabric. In the first chapter we have shown that plain cloths may be ornamented to a certain extent by the alteration of the relative quantities of warp or weft, so as to cause the formation of cords or ribs; these cords would at all times run parallel to each other, either longitudinally

through the piece or transversely. That is the simplest form of ornamentation; and, if proper regard be paid to the proportions of warp and weft, although simple, it is very neat and effective.

28. Twilling.—The next kind of ornament is what is commonly known as twills. These, in their simplest form, are merely ribs or cords running diagonally across the fabric. It would seem at first sight as if this form of decorating fabrics would not permit of much variation, but, in reality, it offers a wide field, and is probably more used than any other. The first and simplest sort of twill is represented by the plan, Fig. 10.



Fig. 10.

In this it will be found that each weft thread passes over two and under one warp thread, and that the order of interweaving is consecutive, that is, each pick of weft passes under a different end of warp, following in the order 1, 2; 3. The result of this is that every third pick and every third end are repetitions, or, in other words, the whole pattern is complete upon three ends and three picks, and that the whole fabric consists of any number of repetitions of these three ends and picks. All these repetitions join to each other in such a manner that the line of twill or pattern is continuous. Although this is the simplest form of pattern-making next to plain cloth, yet, like plain cloth, it is capable of being ornamented by the alteration of the relative quantities and thickness of warp and weft. The twill may be made more or less bold, and the angle at which it runs across the fabric may be altered, and it may be made to present a fine or coarse surface. If the threads per inch of warp and weft be equal, the angle at which the twill will run across the piece will be forty-five degrees, because of its moving from end to end in consecutive order. In this particular pattern either warp or weft must preponderate on the surface of the fabric. As it is presented here, the weft preponderates in the proportion of two to one. If

the pattern were worked in the reverse order—that is, the weft to pass under two threads and over one—the warp would preponderate on the surface in the same degree that weft does now. It is a generally accepted rule—and, as will be shown with other patterns, very properly, too—that whichever set of threads, warp or weft, preponderates on the surface in the order of interweaving, the same threads must also preponderate in the actual number per inch, though not necessarily using threads of the same diameter.

In this case, then, we say weft preponderates on the surface. Then we should have a greater number per inch of weft than warp; and if we do so, the angle at which the twill runs will be less than forty-five degrees. We have here, even in a greater degree than in plain cloth, the power of producing a fine compact fabric, and at the same time ornamenting. But the question will naturally arise, Of what does the ornamentation consist? because the mere alteration of the angle of the twill can scarcely of itself be called an increased ornamentation. Certainly it cannot; but accompanying this altered angle will always be an alteration in the fineness of the surface, and this of itself is an improvement. At the same time, along with this fineness we have more compactness, and consequently increased usefulness. As we increase the number of threads per inch we must decrease their diameters in the proper proportion, otherwise the proper balance will not be maintained between warp and weft, and in all fabrics this must be carefully attended to. Then if we have a greater number of threads per inch, and these threads are proportionately thinner, we must have increased fineness, and consequently a better appearance, a closer and more compact fabric, stronger in proportion to the weight of material it contains.

We have in this one pattern one of the best illustrations in its simplest form of the ornamentation of fabrics where colour is not employed; and it must be

borne in mind that a very large proportion of textile fabrics made for articles of dress are of one colour only, and not a combination of colours, and are dependent upon structural ornamentation for the production of an article which will be pleasing to the eye.

We may now proceed further in the examination of twill patterns.

If we refer again to Fig. 6 we shall find that precisely the same principle of arrangement, so far as the consecutive order of working is concerned, has been adopted as in the pattern of which we have just been speaking, but instead of either warp or weft preponderating on the surface, they are exactly equal. The generally accepted theory of the true structure of a fabric of such a pattern as this is, that warp and weft should be equal not only in quantity but in thickness. That is quite true, though we may produce a perfect piece of cloth without this being actually the case, but the proper proportion or balance must be maintained; we may increase the quantity of weft or warp, but we must reduce the diameters in a proper degree. Although the actual number of threads per inch is not the same in warp as in weft, the true proportion of one to another must be retained. If we do so, we shall alter the angle of the twill, we shall alter the fineness of the fabric, and the increased fineness will add a value to it, render it more pleasing to the eye, and at the same time a more serviceable article.

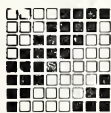


Fig. 11.

Proceeding from this form of simple twill, we may commence to make designs of a larger and more ornamental character. In patterns of the class of which we have just been speaking, whether the repetition occurs every three, four, or any number of ends, we should simply have a series of diagonal bars or ribs, all of equal size, and running parallel to each other. We may add very much to the beauty of the pattern by

varying the size of these lines or ribs, and in doing so would probably add very much to the firmness of the structure.

If we take, for example, the two patterns in Figs. 11 and 12, we have the same quantities of weft and warp on the surface, but one would present a series of parallel lines all equal in size, and the other would present a bold and a faint line alternately. The one showing the variety of lines would be the finer structure, because the warp and weft inter-



F.g. 12.

change more frequently, are more firmly interwoven together, and so secure firmness of texture. There is, however, one thing which must not be overlooked. If we are desiring to produce a heavy, bulky fabric, the pattern Fig. 11 will better enable us to do it, by allowing a greater number of threads to be introduced into a given space. We have, however, still a means left open of producing variety of lines, and yet of securing the requisite weight, and also the requisite firmness and closeness of texture. We have simply to enlarge our design and employ a greater number of threads in the formation of the pattern, and we may vary the lines at will.

29. Arrangement of Designs on Paper.—Before going further, it will perhaps be better to explain to the student who may be just commencing his studies of Textile Fabrics the meaning of the arrangement of patterns in Figs. 11 and 12. The series of vertical spaces represent the warp threads, the horizontal ones the weft, and the black points of intersection indicate that weft, and the open spaces that warp, is coming to the surface. Thus by the use of paper ruled in this manner we have a ready means of conveying to the eye the appearance the pattern will present in the fabric, and of judging of its effect by the order of interweaving.

30. Patterns having a Twilled Basis.—Having now determined the mode of ornamenting by the use of

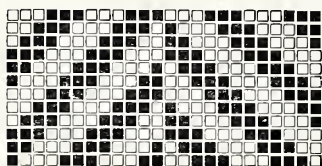


Fig. 13.

simple twills, and their effect upon the structure of the fabric, as affecting not only the appearance of fineness, but its usefulness, we may proceed further, and see what effects we can produce by varying the order and di-

rection of the twills. Here we have an immense field. We may take any simple twill and by altering its direction at intervals, regular or irregular, we may produce patterns of the most elaborate character, and add beauty to the fabric without in any degree affecting its structure or usefulness. Generally, this mode of decorating will assume one of three forms: first, stripes; second check effects; and, third, figures partaking more or less

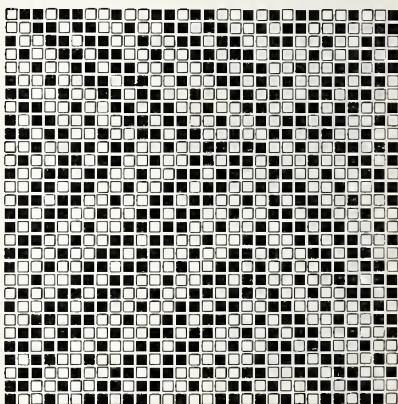


Fig. 14.

of a diagonal character. The patterns in Figs. 13, 14, and 15, are examples of the three orders or classes, each based upon a different twill. They may, of course, all have been based upon the same twill; but by using a different one for each we can more readily demonstrate the use of variety of twills in producing patterns.

In ornamenting fabrics by the use of twills in this

manner, we have a very great advantage over the use of twills running continually in one direction. We can obtain all the variety of lines which the continuous twill would give. We can also obtain variety of form to any extent we please, and we retain the same texture and the same degree of usefulness.

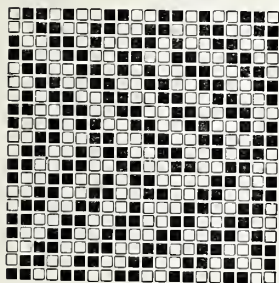


Fig. 15.

Extensive and valuable as this form of ornamentation is, it is really only the first introduction to our work. Certainly, a very large proportion of the fabrics made are decorated from a basis of simple twills only, probably in many cases because of structural advantages; yet the use of twills in other forms may readily be resorted to, and with all the advantages of the simple twill, and greater scope for producing variety of pattern.

Another form in which twills may be, and, indeed, are, very largely used, is shown in Fig. 16, where a very bold diagonal line is run, and a smaller twill running

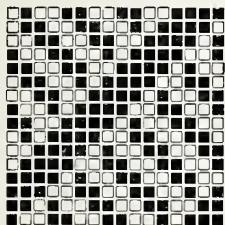


Fig. 16

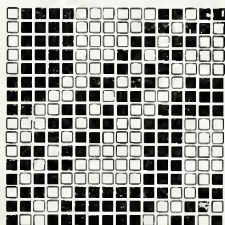


Fig. 17

between and in the opposite direction, and again in Fig. 17, where the same diagonal line is employed, and a small spot introduced between. In either of these orders of working we have an immense field for the production

of variety of pattern. When dealing with the system of combination shown in Fig. 17, it requires great care and judgment to prevent the fabric from becoming too loose in its structure. If we attempt to make the figure too large, or the diagonal line too bold, we are running great danger of interweaving the warp and weft at such long intervals that the fabric will lose its value as an article of utility.

Again, we may produce patterns in twill, forms which are nothing more or less than a series of small figures arranged in diagonal lines, without producing actually one continuous unbroken line, as in Fig. 18, and also in many cases—and these are a very large class indeed—where we have a diagonal line running upon a ground-work of plain cloth. In the case of a pattern upon a ground of plain cloth, we produce a fabric of very firm texture, but not one

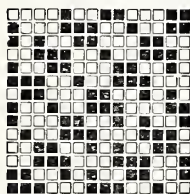


Fig. 18.

into which we can introduce a very large quantity of material. In fact, whenever we combine plain with any order of working, we reduce our power of making either heavy or bulky fabrics, so that whenever our object is to produce heavy goods we must bear this carefully in mind.

31. Twills Arranged in Satin Order.—We must now turn our attention to another class of twill, and one which is of much importance, not only from a decorative point of view, but also from considerations of utility. In the first chapter (Sect. 8) reference was made to satins as being arrangements suitable for the production of fabrics requiring strength in one direction only; but satins are also valuable for the production of fancy patterns; or, rather, perhaps we should say for the present, the principle upon which satins are arranged is valuable when applied to other patterns, as twills.

In that portion of the first chapter to which we have just referred, it is pointed out that the peculiar feature of satins is, that no two succeeding picks of weft interweave with adjoining ends, but that the points of interweaving are distributed regularly, and in such manner that no two can come together. This is dependent upon the principle of arrangement, or perhaps it would be as well to say rearrangement, of the threads, or the points of interweaving. On examining any satin it will be found that those points of interweaving are such distances apart as will be represented by such a number of threads as is not a measure of the total employed in the pattern. Thus, in what is termed a five-thread satin, the points of interweaving are two threads apart; in an eight-thread satin they are three threads apart, and so on. This



Fig. 19.

may be taken as representing the rearrangement of the threads of a regular twill. Suppose we take Fig. 19 as representative of a simple twill upon five ends, and we number the ends 1, 2, 3, 4, 5; we then take these five ends and rearrange them in such manner that the points of interweaving are always at intervals of two from each other, as shown in Fig. 20. By following the numbers in Fig. 20, it will be seen that the threads are simply rearranged.



Fig. 20.

It has already been pointed out that in any pattern where either warp or weft preponderates on the surface of the fabric in the order of interweaving, it must also preponderate in the actual quantity of yarn employed, and that this applies more especially to satins. In the case before us, where we have a twill and satin side by side in Figs. 19 and 20, and we show that the satin is simply the rearrangement of the twill, it would appear that the rule should apply equally to both; but it cannot quite do so, because of one interweaving warp

with weft in consecutive order, and the other at intervals. Now, if that be the case in this kind of simple twills, it is even more so in that of other twills. Let us examine the two patterns Figs. 21 and 22.

Here we have the separate warp threads numbered in exactly the same manner as Figs. 19 and 20, the only difference being that a greater number of threads are occupied, and therefore the order of rearrangement is different, though it is based upon precisely the same principle—namely, that the interval in the order of interweaving is equal to the first number which is not a measure of the total.

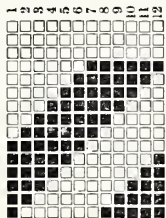


Fig. 21.

To make a perfect fabric with the pattern in Fig. 21, warp and weft should be equal in every respect. There is the same quantity of each on the surface, the order of interweaving is consecutive, and the angle of the twill would be one of forty-five degrees, but in the rearrangement, as in Fig. 22, the conditions are altered. True, there is still the same quantity of warp and weft on the surface; the angle of the twill is also one of forty-five degrees, but the order of interweaving is completely changed. In the pattern, when worked as a regular twill, each end as it comes to the surface is supported for five-sixths of its length by the end adjoining it on each side, consequently the cloth will look fine and compact if the threads are just set so close as to touch each other, or if they occupy a space each equal to their diameters.

The same remark will apply exactly to the weft, but in the pattern as shown in Fig. 22 alternate ends are brought to the surface, as in the formation of plain cloth, but they remain on the surface for a longer period than in plain cloth. If we weave this pattern with the warp

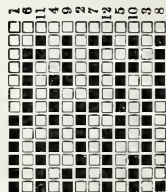


Fig. 22.

set the same distances apart as for the regular twill, each warp thread will stand separate and distinct, and the cloth would not be nearly so firm as in the common twill. We must compare patterns of this class with plain cloths constructed so as to form a rib across the piece; we must have the warp threads fine, and so closely set that all those on the surface will be in actual contact with each other, or so near as not to show any division. The weft is con-



Fig. 23.



Fig. 24.

tained between the warp, it will therefore be laid straight, and the warp will bend round it. Another example is shown in Figs. 23 and 24; and, further, in Figs. 25 and 26.

In both the instances of regular twill patterns, Figs. 23 and 25, the quantities of warp and weft are nearly equal, and the order of interweaving would produce a very firm fabric. In the rearranged patterns, in Figs. 24 and 26, each pick is as nearly as possible a plain pick—that is, under and over alternate threads—and for at least one half the pattern two picks together are under and over the same threads. Again, they differ from the pattern in Fig. 22 in the angle at which the twill runs across the fabric. In Fig. 22 two

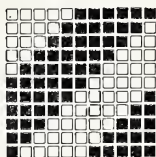


Fig. 25.

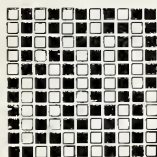


Fig. 26.

threads come to the surface together at regular intervals, in Figs. 24 and 26 they do not, taking in both cases the black dots as indicating weft. In Figs. 24 and 26 the number of ends employed is an odd number, while in Fig. 22 it is even. Although all the three patterns in Figs. 22, 24, and 26 are arranged upon the same basis—they are

all simple rearrangements of a regular twill—they will produce different effects in the fabric, first, as to the angle,

and second, as to the regularity of the twill. However, they all possess one feature in common, namely, that they are akin to the corded or ribbed class of plain cloth, but the rib will not be in the direct line of the weft, and at right angles to the warp, but will be more or less of the nature of a diagonal line. They all require that the warp shall be closely set, and the angle of the twill varies in each case as the relative quantity of warp and weft varies.

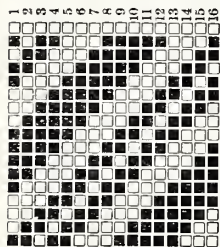


Fig. 27.

We have in this principle of rearrangement in satin order a very easy and simple method of producing patterns for ornamentation, and if proper relations be maintained between warp and weft according to the order of interweaving, our fabrics will be of a most useful character. In fact, in many cases the rearranged pattern will give a more useful fabric than the simple twill, just in the same manner as the corded plain cloth is a more useful and stronger cloth than the plain cloth of the pure type.

The rearrangement of twills in satin order will, in a great many cases, produce patterns of a very ornamental character, and presenting an appearance greatly different from that of the original twill from which it comes. This is well illustrated in Figs. 27 and 28.

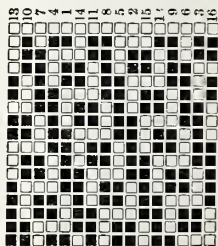


Fig. 28.

In the former we have a twill of ordinary type, but in the latter we have one of a very different character. Not only is it a distinctly ornamental twill, but the angle at which it runs is altogether different; the order of interweaving is different so far as the successive order of each end is concerned, though the ends

taken individually are precisely the same. In fact, if we examine the ends and their numbering, we shall see that Fig. 28 is Fig. 27 rearranged. It would be a very easy matter to give a very large number of illustrations, but the limited space will not permit it, and the number of patterns capable of being produced has already been fully illustrated in my "Album of Textile Designs."

It was pointed out on page 38 that in many cases the rearrangement of a twill in satin order very frequently altered the angle of the twill, and by the alteration of angle, as well as the order of interweaving, would necessitate the alteration of the relative quantities of warp and weft. This is true in the great majority of cases ; if the rearrangement takes place in the warp threads, the angle of the twill generally runs in the direction of the weft, and so approaches a ribbed fabric, as shown in Figs. 24 and 26, but in some cases the angle of the twill will remain the same as in the original, though these cases are not very numerous. In some few the angle will be more in the direction of the warp. The alteration of the angle is mostly dependent upon the order of rearrangement, but in a few instances it is affected by the order of interweaving of each individual thread. In any case it is a matter of the greatest importance that the relation of warp to weft should be carefully adjusted to the pattern, so as to secure a proper balance of structure, and so make the fabric serve all useful purposes to the utmost.








There is one point here which may be observed : if the fabric is to be fine in the warp, or to be able to bear great strain in the direction of the warp, it is generally most readily obtained by rearrangement of the warp threads, as already shown ; but if it must be fine in the weft, or be able to bear lateral strain, then it may be readily obtained by the rearrangement of the picks or weft threads. The ornamentation of patterns of this character need not be dependent only upon the particular

class of pattern shown in Fig. 28, but as in ordinary twills it may consist of a variety of lines, or, in other words, by variation in the thickness or width of the ribs.

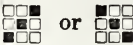








From what has been said the formation, and more especially the rearrangement, of twills is intended to serve the joint purpose of ornamentation and increased usefulness; but rearrangement of twills may be made for the sole purpose of ornamentation, and we have in this mode of working an immense field. It may be said that by the rearrangement of twills we have a means of producing a large variety of fancy patterns by a purely mechanical process, and that for their application to the fabric only judgment in selecting is required so as to apply that class of pattern which is most suitable for the class of fabric to be produced.


32. The Production of Pattern by Rearrangement in Different Orders.—The system of rearrangement of which we have been speaking is one of the most perfect, but, as has been shown, it will produce generally but one class of pattern. We must now look for systems which will give us greater variety. We might look to what is commonly known as permutation to supply us with this, but we must be careful not to be led away by false ideas of the number of patterns we can produce, or the modes of producing them.

According to the system of permutation, two objects can be placed in two positions in relation to each other, three objects can be placed in six positions, four objects in twenty-four positions, and so on. At first sight it would appear that we may produce so many patterns upon any number of ends as permutation will give us positions, and that simply by the rearrangement of those positions. Further, we might say that as each end of warp must interweave with a given number of picks of weft, the number of patterns capable of being produced upon a given number of ends and picks would be repre-

sented by the permutation of ends and picks together ; thus, if we take four ends and four picks, as represented here,  there are sixteen points of intersection of warp with weft. Now, the permutation of sixteen gives us a number represented by fourteen places of figures, or 20,867,685,888,000, so that it would appear that that would be the number of patterns we can produce. We must see what is the real state of the case. Patterns must have some definite order in their arrangement, and they must also be so arranged as to be continuous. Any pattern must be so that it will join to itself on all sides, and be perfectly continuous if extended or repeated in any direction. Let us take, for example, a plain cloth.  Here we have a complete plan of a plain cloth.  Two ends and two picks are used ; there are four points of intersection. Those two ends and picks would be repeated any number of times so as to produce the width and length of fabric required. Suppose we exchange the places of the two ends, thus,  and repeat this rearrangement any number of  times, we should not produce a new pattern ; when extended they would both be exactly the same thing. Again, in exchanging the ends we have also exchanged the picks, so that it is quite incapable of further alteration in this respect, and all further efforts to produce patterns in this direction will be in vain. We will go one step further, and alter the order of interweaving, thus,  Here we make three of the four spaces black, or  make weft come to the surface at three of the four points. If we were to exchange the places of either ends or picks the result would be the same as in the previous case—that is, the pattern being repeated, the threads would be made to bear the same relation to each other as they did originally, so that we can go no farther in that direction. There is another point also which reduces this proposition to an absurdity. It will be seen that one pick of weft passes *over both* the *ends* employed, and also

that one end passes *under both picks* ; therefore, no interweaving can take place, and cloth will not be formed.

It must always be borne in mind that whatever number of ends or picks are employed in the formation of a pattern, we are confined to that number, and the whole fabric is a series of repetitions. That being the case, plain cloth is incapable of any variation in the order of interweaving, although, as previously shown, it may be made the *basis* of a system of ornamentation. If we take three ends and three picks we have apparently some room left for ornamentation, but in reality we are again limited to two positions, thus,  We may place our three ends in any  or  order we please, but they will always produce exactly the same thing—a regular twill running from left to right or from right to left ; and any alteration in the order of the ends will produce an exactly corresponding alteration in the picks. In fact, it is as if we take three straight lines ; we can produce but one figure from them—namely, a triangle. We may obtain an apparent alteration in the twill by bringing weft over two warp threads instead of one, thus,  but it is the same pattern. We are merely  substituting weft for warp on the surface, and  the back of one fabric will be exactly like the face of the other. If we take four ends we have a little more scope for the production of patterns, but it is still very limited. We may run our twill in one direction or the other, or we may break the pattern into two portions, and reverse the order of position of one of the pairs, thus,  and so produce a quite distinct effect, but so far  as rearrangement goes, that is all we can do,  every other rearrangement producing precisely the same result. We have, however, one advantage, which increases as the number of ends employed increases—that is, we can vary the order of interweaving more—though with four ends we are limited to two—the one given above and

that in which we allow weft to pass over and under two warp threads, thus,  each being equally capable, of the same variation.

If we were to proceed in detail through each number of ends in succession, we should find at each step that we have not only the advantage which has just been pointed out—the power of varying the order of interweaving—but greater variety of rearrangements. We have not only the satin arrangement already spoken of, but a great number of other orders. For example, we might transpose the ends in twos, threes, fours, or any number—thus, 2, 1, 4, 3, 6, 5, or 3, 2, 1, 6, 5, 4, &c. Each of these transposed orders may be further rearranged. After we have transposed, say, in twos, take the resulting pattern and rearrange it in satin order, the pattern resulting from that in some other order, and so on, until we eventually return to the original starting point. There is but the one thing to bear in mind—that all our rearrangements must be regular; there can be no pattern without regularity and order. If we do not carefully attend to that, we shall have simply a jumble of threads together and no pattern.

33. Patterns Produced by Combination of Twills.—This method of producing patterns by rearrangement is but the first step in the production of new designs for fabrics in a systematic manner. Great as is the number of designs which may be obtained by this mode of working, it is small compared with what may be obtained by other and equally systematic methods. We may turn our attention next to what is known as the doctrine of combinations, and from that we shall be able to obtain an infinite variety. We will first examine into the system of combinations, and then see how far we can apply it to the work in hand. Although, as has been shown, permutation gives nominally great power of producing patterns, yet, in reality, when applied in regular order, as is necessary for designs, it is limited. It might

almost be said that combinations give an unlimited power. The combination of two square pieces, each divided diagonally in two colours, is said to be capable of being made in sixty-four different ways. According to Prestet's calculation, the combinations possible of the twenty-four letters of the alphabet taken by twos, then by threes, and so on, amount to a number represented by thirty-three places of figures, or thirteen billions of billions, or 139 quintillions, or so many different words may be produced. There is this difference between the combination of such things as the letters of the alphabet and the ends of a pattern—whereas the letters of the alphabet are all different, the order of working of the ends of a pattern should be similar. Still, although the working of the ends should be similar, the order of interweaving of the picks need not necessarily be similar; and again, any two letters will admit of but one combination, but two patterns will admit of a number of combinations, and at each one produce a new pattern.

Combinations are generally taken as denoting the placing together of objects, quantities, &c., and their alteration or variation in all possible ways. Thus, one object will admit of no combination; two objects will admit of one combination only, provided they are simple objects, but if they are not simple ones—if they present different appearances on their different sides, as in the case of the coloured squares—then they will permit of a great number of combinations; and further, as we increase either the variety or the number of objects, we increase at the same time the number of fresh combinations possible. We will proceed first with the combination of simple objects in twos. Two objects will admit of one combination only—viz., AB; three objects will admit of three combinations—AB, AC, and BC; four objects will admit of six combinations—AB, AC, AD, BC, BD, CD; five objects will admit of ten combinations; and so on. The combination of any number of objects will proceed ac-

cording to the triangular numbers 1, 3, 6, 10, 15, 21, &c., or a general formula will be $\frac{N \times (N - 1)}{1 \times 2} = \text{combinations}$; that is, let N represent the number of objects—suppose 6—then $\frac{6 \times (6 - 1)}{1 \times 2} = 15$; or fifteen will be the number of combinations which may be produced from six objects.

Now let us see how this will apply to patterns, and how far we may extend it by placing the patterns in a



Fig. 29.



Fig. 30.



Fig. 31.



Fig. 32.



Fig. 33.

different position in relation to each other. In Fig. 29 we have a combination of two seven-end twills, pick and pick alternately; that is, the first, third, fifth, &c., picks would form one complete seven-end twill of themselves, and the second, fourth, sixth, &c., picks would form one pattern. The two patterns are placed together alternately, one pick of one and one pick of the other, and so form a new pattern. Now, as we have just pointed out, two simple objects permit of one combination only; but two patterns can scarcely be called simple objects. In the first place, each pattern occupies seven ends, consequently they can be placed in relation to each other in at least seven different positions, as shown in patterns 29 to 35.



Fig. 34.

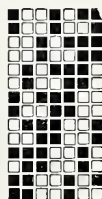


Fig. 35.

Then, after we have found by the formula given

how many combinations we can produce from a given number of patterns, we may multiply that by the number of ends in the pattern, because we can combine them in as many positions as there are ends employed.



Fig. 36.



Fig. 37.

Upon seven ends suppose we make, say, sixteen simple twills—not a very difficult thing to do.

We can combine these sixteen twills in $\frac{16 \times 15}{1 \times 2} = 120$ times in one position in relation to each other, and as there are seven ends, we may produce $120 \times 7 = 840$ patterns

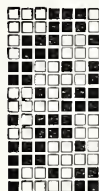


Fig. 38.



Fig. 39.



Fig. 40.



Fig. 41.



Fig. 42.

by combinations. But we have not done even yet, for each of these simple twills is capable of rearrangement, and they can then be combined in their rearranged form. Thus, Figs. 36 and 37 are rearrangements in satin order of the two patterns of which Fig. 29 is composed, and the patterns 38 to 44 are combinations of those rearrangements. The appearance presented by these patterns is very different from that of those composed of straight twills, so that we have here again 840 more patterns possible. But this is only one rearrangement. Many others may be made; each again may be dealt with as before, and so give us



Fig. 43.



Fig. 44.

an unlimited field for the production of new designs. Perhaps, in producing this great number of patterns, we should find in many cases that we have repetition, though the repetition would not take exactly the same form, but probably the pattern would appear in reverse order; still, it would be none the less the same pattern, and again, many of the patterns would come so nearly alike that they would amount practically to the same thing in the fabric. However, the principle is valuable as enabling us to produce a large number and variety of designs with the least possible amount of labour, and giving us a power of producing patterns of even a more elaborate character than the combinations previously alluded to produce.

So far we have been speaking of combining our twills in regular order in twos only, but we may vary the order as much as we like, provided only it is on a systematic basis; and we may combine in threes, fours, or any number we please. We will see how far the combinations in threes or any number will enable us to go. If we combine in threes, three objects will admit of but one order, four objects will admit of four orders, ABC, ABD, ACD, and BCD, and five objects will admit of ten combinations. Thus for combinations in threes a general formula will be $\frac{N}{1} \times \frac{N-1}{2} \times \frac{N-2}{3}$, and so on; and the same formula may be extended to the combination of any number of objects, and by any number at one time; and the formula for determining the number of combinations will be as above, continued to M, the number of factors. In these series, as in the series of twos, each pattern is capable of being placed in relation to each of the others in as many positions as there are ends used. So that we have surely a sufficiently wide field for the production of designs of this class without having in any way to draw upon imagination, but we have to exercise a proper discretion in applying them to the fabric.

CHAPTER IV.

STRIPES, CHECKS, AND FIGURES FROM COMBINATION OF
DIFFERENT TWILLS.

34. The Effects of Combination of different Twills in Stripe form.--We may now proceed to deal with the production of designs from the combination of twills or other patterns, and in doing so we must not only take into account the pleasing effects we may obtain from such combinations, but also the relations of the structure of fabric of one pattern to the structure of another pattern; and thirdly, the economic use of patterns in the process of weaving. We have already pointed out in reference to Figs. 13, 14, and 15 that patterns may be readily produced from simple bases, by combining them so as to form stripes, checks, and figures. In all those cases the pattern is produced by combining the twill with itself; that is, it is allowed to run for a given number of ends or picks in one direction, and then for a given number in another direction, so forming the pattern by the twill lines running in various directions. This is probably the easiest mode of producing patterns of a large size, and also of an elaborate character, though it must of course be borne in mind that there will always be a certain stiffness about them. One chief value of patterns arranged upon this basis is their economical production in the loom. The stripes or checks may be varied to any extent; the pattern may be as large or elaborate as we please; but if proper care is taken in their arrangement there are only a limited number of different orders of working; that is to say, the whole pattern consists of a twill, which is represented by a limited number of ends. These ends are simply repeated over and over again, perhaps not exactly in the same order, but the

order is varied according to the working of the pattern. Still a few ends are representative of the whole, and consequently a few "healds" will suffice in the loom for weaving the pattern. It only requires that proper care be taken to arrange the order of succession of the ends, and the order in which they are drawn through the healds, to ensure the proper pattern being produced in the most economical manner.

In the principle of rearrangement with which we dealt in Chap. III. we have a power of producing patterns of much greater variety than we can obtain by the mere combination of a simple twill with itself, at the same time that we preserve the economical mode of working. But in its application very great care becomes necessary to ensure the fabric being perfect; and not only for that reason, but also because although we may combine patterns which have the same common base, and so produce a pattern which can be worked with a small number of healds, yet we may so combine the two that they cannot be worked with a small number. And again, we must bear in mind the similarity of the two patterns, or their bases, must not be imaginary but real.

We will examine first into the question of the combination of patterns coming from the same base, but producing different effects in the fabric, and requiring a rearrangement of the proportions of warp and weft. If we refer to Figs. 21 and 22, we shall find an illustration of the fact that the rearrangement of the threads of a pattern will require an alteration of the relative quantities of warp and weft. Now, these two patterns come from the same base. Every separate end in one pattern is raised and depressed exactly in the same order as the ends in the other pattern, only they do not bear precisely the same relation to each other in their order of succession, as is indicated by their numbers. But one can be woven upon the same healds as the other; that is, the heald which carries

thread No. 1 in one pattern might also carry thread No. 1 in the other, and so with thread No. 2. This is usually the first point looked to in the arrangement of patterns, because if we can produce an elaborate design upon a small number of healds, we can do our work in the most economical manner; and so far as the two patterns to which we have referred are concerned, this can be done readily, but we must look carefully to the effect in the cloth. We have already seen that in the two patterns to which we are now alluding the one will require considerably more warp threads per inch than the other, or if we were to weave them both from the same warp, with the same size of yarn and the same number per inch, there would be a great difference in the two cloths. Then it must be very evident that if we combine these two patterns in the same cloth in stripe form, there will be a difficulty in the formation of the fabric in consequence of one portion interweaving more loosely than the other. The effect will be that the warp forming one portion will gradually become slack, and an effect commonly termed "cockling" will be produced. If we make very small patterns, or patterns occupying only a very small number of ends, this would not perhaps be so apparent; but if the pattern be large, then it would become a serious objection, and in fact it would be almost, if not quite, impossible to produce a perfect piece of cloth, unless the two patterns were made from different warps, and came from different warp beams in the loom.

35. Combination of Different Twills in Check Form.—If we take the same two patterns, and combine them in a different order, say so as to form a kind of chequered pattern, as in Fig. 45, we shall obviate the difficulty to some extent. Here it will be seen that each set of threads works first to one pattern and then the other alternately. That being the case, one will neutralise the other, and so prevent the "cockling" which will occur in the case of a stripe puré and

simple. We have in this case obviated one difficulty, but care must be taken that in doing so we don't fall into another. If we are working in this stripe form, by a simple combination of the two patterns Figs. 21 and 22 side by side regularly, there would be no difficulty about weaving the pattern with the smallest number of healds possible—namely, twelve—because one portion is simply the other rearranged, so that it is really a continual repetition of the same twill, but not with the ends always in the same consecutive order. The same may be said also of the design Fig. 45, but as the two orders of working exchange places at intervals, unless those exchanges are properly arranged, the two sets of warp threads will not be exact fac-similes of each other; and unless they are so, they could not possibly be woven with the same healds.

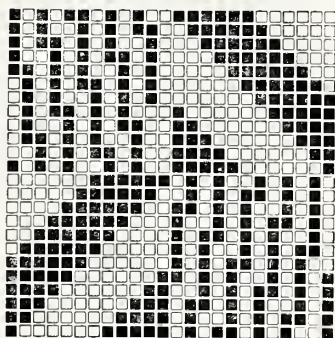


Fig. 45.

It is not intended here to enter closely into the question of "drafting," as that subject is fully treated in my "Treatise on Weaving and Designing Textile Fabrics;" but it is necessary to refer to it so as to enable the student to more fully understand the application of design to the fabric from a practical point of view. For the purpose of explaining this more clearly we will refer to Fig. 46. This is, in all appearance, exactly the same pattern as Fig. 45. It is, in fact, the same combination, and made in apparently the same manner; but if the threads be carefully examined all through the pattern it will be seen that there are no two exactly alike, so that although we are making the same pattern, exactly the same combination, we have

made it more difficult and more costly to produce, by requiring a greater number of healds to weave it with.

36. The Method of Joining Patterns in Combination.—In arranging patterns of this kind, the manner in which the two patterns join together requires much care. The point of junction should be such as to show no imperfection, that is, the weft or warp should not pass

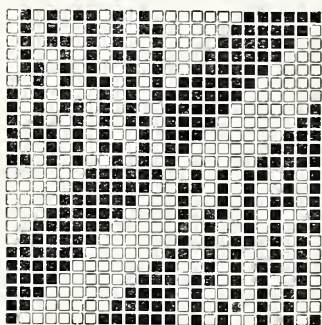


Fig. 46.

under or over a greater or less number of threads at that point than they do anywhere else. There are instances where some little imperfections must occur at the junction, but all care must be exercised to reduce them to a minimum, and present the fabric to the eye perfect or nearly so. In this system of producing patterns we have the basis of most of the designs for

fabrics for men's wear, and we certainly obtain a very great variety; and they are used both for heavy fabrics, such as coatings and trowserings, and for many other cloths.

37. Effects upon the Fabric.—In the illustration in Figs. 45 and 46 of the difficulty of combining two patterns one of which is a rearrangement of the other, we have not by any means shown all the difficulties, nor in the simplest form. In dealing with patterns which appear easy and simple, and in which the principle of rearrangement is carried out in its simplest form, we may find that the effect of the two portions in the fabric is very different; and we cannot be too careful how we place them in juxtaposition. Suppose we take a pattern based upon a simple six-end twill, as in Fig. 47. We may have no doubt or difficulty about

its working. The twill occupies the largest portion of the fabric ; the stripe, *a*, occupies but a small portion, as does also *b*. In the order of interweaving of these three portions it would seem that there could be little difference, and there certainly is not so much difference as there may be in some patterns, but just enough to require caution and proper arrangement. It will be evident that in the twill portion the weft and warp will bend round each other in an equal degree, and consequently that the same quantities of warp and weft will be required to form a perfect cloth. The same may be said of the stripe *b*, although it is not the same kind of structure ; but there is this difference between this portion and the twill : whereas in the twill every succeeding end and pick interweave differently—that is, not under and over the same threads—in the portion *b* there are three warp ends, and three weft picks together exactly alike, and therefore a greater number of threads per inch of the same size of thread could be introduced into a fabric of the structure *b* than of the twill cloth. In the portion *a* of the pattern each weft pick passes between alternate warp threads, and three succeeding picks are exactly alike, so that the warp in this case cannot exercise power over the weft, and make weft bend round warp in any degree, but the warp must bend round the weft. That being so, to make a perfect structure of the fabric there should be a greater number of warp than weft threads per inch. It must be clear that if we were to combine three orders of working such as these in large patches or stripes, say of one inch each, there must be some



difficulty in obtaining a perfect cloth. As has already been said, the difference in this case is not so great as in

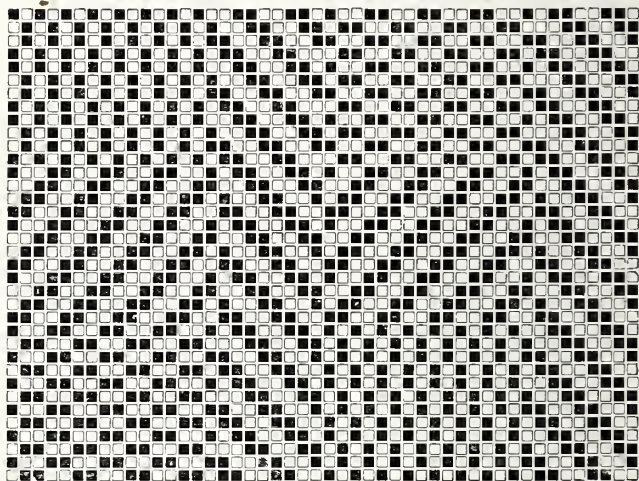


Fig. 48.

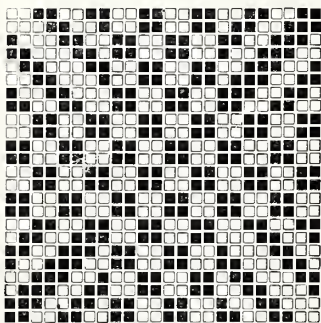


Fig. 48a.

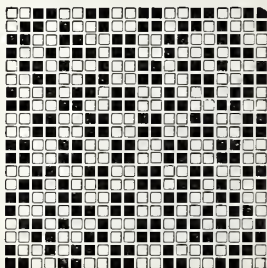


Fig. 48b.

many patterns which are combined ; still, it is sufficient to cause trouble if used in large patches. Then there are

only two alternatives: we must use the stripes in small quantities, so that the difference in the order of working cannot assert itself as it would in large stripes; or we must have the relations of warp and weft in our cloth such as to produce as nearly as possible a perfect cloth in *all the three* orders of working at the same time. Of course, each one will be something short of the true structure of a cloth of the class to which it belongs, but will not be so far removed from perfection as to be positively faulty or imperfect to the eye. We have next to show that from this system of combination, patterns of a very elaborate character may be produced, either all coming from the same simple base, or a combination of patterns of a different character. For this purpose we have prepared a few designs shown in Figs. 48, 48A, and 48B.

38. Combination of Twills occupying Different Numbers of Ends.—Although we have a wide field in the class of patterns and combinations we have been dealing with, yet it is only the first step, and our power of obtaining varied patterns increases enormously as we depart from this simple system of combinations. At the same time, many of the patterns with which we are now about to deal are built upon the same basis—that is, the same principle of combination is employed.

We have already pointed out how patterns may be readily produced by the combination of two twills.

In the examples given in Figs. 29 to 35 we have simply the combination of two twills, each occupying the same number of ends; but in many cases the combination of twills

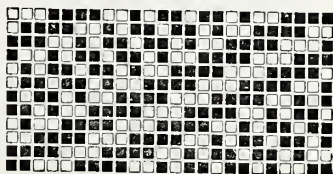


Fig. 49.

occupying different numbers of ends or picks may be very desirable, and we shall produce large patterns, and in many cases very elaborate ones. Take, for ex-

ample, the pattern Fig. 49 ; we have the combination of a simple four-end twill with a three-end twill, an end of each alternately. It will be seen of this pattern that it differs from the combination of two twills, each occupying the same number of ends, inasmuch as the two twills in this case fall in relation to each other in all the positions possible ; consequently, we have all the variety in this one pattern which is obtainable, and, what is quite as important, the pattern can be produced in the most economical manner. As it consists of two simple twills, one occupying four and the other three ends, the whole pattern will require but seven healds for its production in the loom. We must, however, examine patterns of this description from every point of view. It is very easy and pleasant to see the advantages we may obtain by working in a certain manner, but we must also, at all times, look for whatever disadvantages may accompany it. It has been pointed out already that every end in a pattern should work as nearly as possible alike, so as to prevent variation in the tension during the process of weaving, or that some other safeguard must be resorted to to counteract any varying tension. In the pattern before us—Fig. 49—we have a combination of two twills which interweave differently, one passing over and under the weft at intervals of two threads, above and below, the other over two and under one weft thread, or *vice versa*. That being the case, the pattern which interweaves most frequently, which has to bend round the weft more than the other, will of necessity “take up” more, or, in other words, require a greater length of yarn to produce a given length of fabric ; therefore, if the two threads are being given off side by side an equal length of each, one must of necessity gradually become tighter than the other. In this particular pattern the difference would be very slight, perhaps not so much as to cause any trouble to the weaver. That would depend to some extent on the class of material employed. If the thread be of an elastic nature—one

which would stretch some length without breaking—it would be quite easy to produce this pattern; but if the thread be of a stiff, brittle character, it would probably be a little difficult. Of course, there is always this to be said of patterns combined alternately, or, as it is technically termed, “end and end.” Although there may be considerable difference in the order of working of the two patterns combined, the fact of their being alternate will tend, in a great measure, to neutralise the difference in the working, because that which interweaves most loosely will exert very little power over the weft, and so when the thread which is interweaving more intimately begins to have a greater tension than its neighbours, it will cause the weft to bend a little out of its course, and so decrease the tension upon the warp thread.

In applying patterns of this character to the fabric, all these considerations must be carefully taken into account; as also must one or two other matters which will have a material effect upon it. We have already shown how the elasticity or rigidity of the warp threads may affect it; in the same manner, if the weft be of a very stiff material—one upon which the warp threads cannot exert much force—the warp has no opportunity of recovering itself by bending the weft. Again, if the warp threads be set very closely together, it is very difficult for the warp to act upon the weft, but the warp will always bend round the weft. In this case, care must be taken that the difference in the order of working is as little as possible; in fact, it ought to be accepted as a general rule, unless there be some specific object in view—a desire to produce some special effect—that the working of each thread in the pattern be nearly alike. It very frequently happens that this is the case. For example, one half or any portion of the warp may be desired to form the ground-work of the fabric, and the other half may simply be used for the purpose of ornamentation. In such cases it may be a great advantage for the threads which form the ground-work to be as

tight as possible, so as to throw up the ornamenting threads prominently. But even if such is not the case, and it is desired to keep each thread nearly equal in tension, any inequalities in the order of working which would affect the tension may be perfectly neutralised in the process of weaving, by allowing the two sets of threads to come from two separate warp beams, and regulating the amount to be given off exactly according to the length required by the increased or decreased intervals of interweaving. It requires some little skill on the part of the weaver to accomplish this satisfactorily, but it is not one of the most difficult tasks, and it certainly is one which, as we shall have to show in reference to other fabrics, must be frequently resorted to.

In the case of fabrics where difficulties might arise in consequence of the variation in the tension of the warp threads, we are still at liberty to apply this class of pattern by simply inverting it, making warp become weft and *vice versa*, or, in other words, combining the patterns pick by pick, instead of end and end alternately. If we do this, the pattern cannot be woven on so small a number of healds in the loom as in the other case, and of course the relative quantities of warp and weft must be reversed to produce a perfect fabric, but the ornamentation will be equally effective.

39.—When Patterns produced by Combinations are Complete.—



Fig. 50.

One question might probably arise in the mind of the student as to the extent of the pattern produced by the combination of such simple twills as those occupying three and four ends respectively. In all

cases of the combination of two patterns the design must be carried out to such a point as will give both patterns employed complete at the same moment. In the case

before us, when the four-end twill is once completed the three-end twill is once and one-third complete; when the four-end twill is twice complete the three-end twill will be twice and two-thirds complete; and when the four-end twill has been three times repeated, the three-end twill will have been four times repeated; they will, therefore, both be complete at the same time. Then, as the patterns are combined end and end, twelve ends will be required of each pattern to complete the design, or twenty-four ends in all; but only twelve picks will be required, because in the warp the patterns are alternate with each other, but in the weft they are running simultaneously; or if the patterns are combined pick and pick instead of end and end, twenty-four picks and twelve ends would be needed.

A very great variety of patterns may be produced by this method of combinations, and, like those with which we have previously been dealing, they are made in a systematic manner. It will generally be found that the best patterns, and those showing the greatest variety of workings, are produced by the combinations of patterns, each occupying such a number of ends that they have no common measure. If we combine, for instance, two occupying six and four ends respectively, we shall have the pattern complete upon twenty-four ends—twelve of each—and twelve picks; or one of the twills will have been repeated twice over, and the other three times. In that case, the two patterns would be placed in three positions in relation to each other only, as shown in Fig. 50. This certainly makes a fairly effective pattern, but it does not show such great variety of working. If we alter one of those twills which form the base—make the six-end into seven, or the four into five—we shall alter the whole effect. In the one case we should require twenty-eight ends of each pattern, or fifty-six in all, and twenty-eight picks; in the other we should require thirty ends of each twill, or sixty in all, and thirty picks, and in each case

the two twills will be placed in all the positions in relation to each other which are possible, as shown in Fig. 51.

40. The Combination of Rearranged or Irregular Twills.—In the combination of twills which occupy

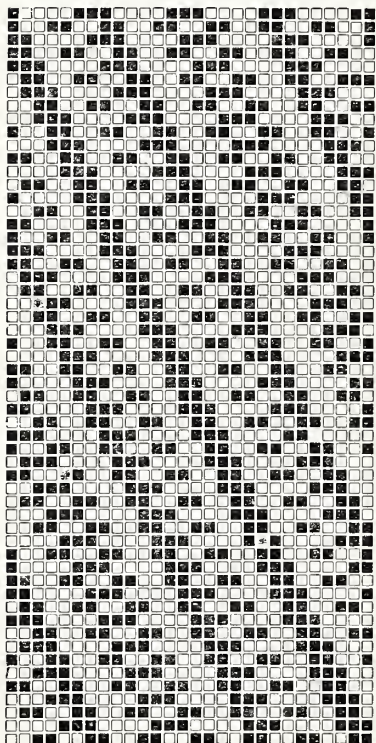


Fig. 51.

different numbers of ends we may deal with them in the same manner as with those which occupy the same number, that is, combine them as simple regular twills, or one twill regular and the other rearranged, or both rearranged. Of course we cannot place them in as many positions in relation to each other as we can when they occupy the same number of ends, and so produce a great number of different patterns, because in one combination we have the two patterns in all the positions possible. Of one thing we must be careful—

in combining regular with broken or rearranged twills the result will be irregular. In fact, we may be guided by the well-known axiom that equals added to equals produce equals, &c., and put it into language which will suit the

case, and say regular twills combined will produce regular patterns, regular combined with irregular will produce irregular patterns, and irregular combined with irregular will produce regular patterns. These axioms must be carefully borne in mind, because a very great proportion of the patterns produced by the combination of regular with irregular twills are such that they could not properly be called patterns, but some few may be sufficiently regular to be worth while using and calling patterns. Take, for example, the patterns in Figs. 52 and 53 ; in each case

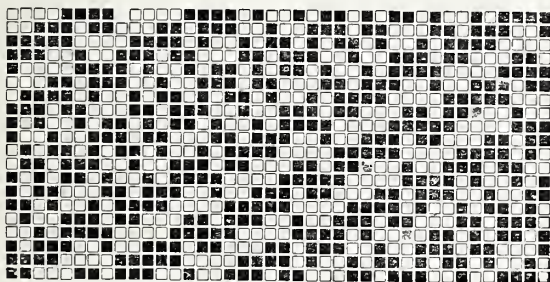
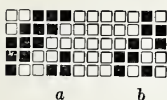


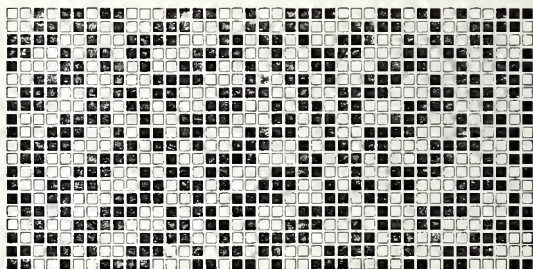
Fig. 52.



we have a combination of regular with irregular, the basis of the combination being shown at *a* and *b* in each. In the one it will be

seen that the four-end twill is rearranged, or in broken order, and in the other the five-end twill is in the rearranged order. Now, in both patterns, more especially in Fig. 52, there is some show of reason for the result being regular. Although the twill is rearranged, and the pattern resulting is not what is commonly known as a regular twill, yet there is a great amount of regularity about it. It runs continuously in the same direction, although the angle is not one of forty-five degrees, as in the four-end twill which accompanies it; yet the fact of the rearrangement being a regular

one and giving a continuous twill, will cause it, when combined with another regular twill, to produce a regular effect. But although the effect has the appearance of regularity, it is not the character of regularity which is to be found in the patterns resulting from the combination of regular twills, but rather what might, perhaps, be termed regularly irregular; yet the pattern is a pleasing one, and is of a style which might with advantage be employed in a great many fabrics. This illustration will serve as a guide as to what will



F g. 53.



produce good patterns. Although we say that the combination of regular with irregular will produce irregular patterns, yet, when the irregularity of the pattern which is to form one of the bases is of the character shown here, the resulting pattern will, in all probability, be a satisfactory one; but it is not generally desirable to resort to such combinations, unless the intention is to produce some special effect resembling a figure, as these combinations usually do

41. Elongated Twills.—We have not yet done with the arrangement of patterns which assume a twill form, or which have a twill for their base. We may vary them still further than we have done in an infinite degree, but there are one or two special modes

of arranging them which it will be necessary to deal with here. It was pointed out in an earlier chapter that twills often run across the fabric at an angle of more or less than forty-five degrees—that is, they may be nearly vertical, or nearly horizontal; and in many cases such twills may be most readily produced by the combination of two or more twills “end and end,” or “pick and pick,” as the circumstances of the case may require. Although that is a ready mode of producing such patterns, yet very frequently when we desire to procure some special effect we may more readily obtain it by the simple process of elongation. We may take any ordinary twill for the base of our pattern, and draw it out or elongate it to any extent by simply making any number of ends or picks alike, as in Fig. 54; then we may alter the pattern so as to prevent a number of picks being alike, as it is in this pattern, by introducing some order of working twill or otherwise between the main twill, as in Fig. 55, when a small twill is run between the main twills, and in the contrary direction.

This not only prevents more than one pick being exactly alike, but gives variety also to the pattern. The small twill may, of course, be varied, as well as the main twill, and it may be made to actually join, or finish quite clear of, the main twill; though it is generally best not to let the two come in actual contact. Thus the pattern will be more decided and clear. In many cases figures or spots may be substituted for the small twill, or even introduced along with it, and so give again greater variety and character.

Twills or patterns of this description are, after all,

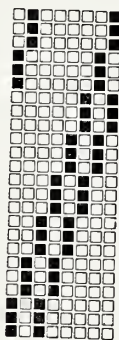


Fig. 54.

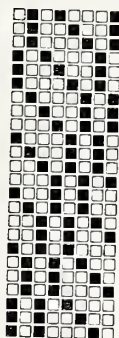


Fig. 55.

only combinations of simple twills. If the picks in succession be examined, they will be found to consist of a series which, if separated from each other, and if all those which work in the same order be put together, would form a twill of themselves, so that the whole would be the result of the combination of two, three, four, or more simple twills. The same result might, of course, have been obtained by the simple process of combination. But what would be the advantage or disadvantage of either mode of working? In the first place, when we proceed upon the system of combinations, if we desire to produce some special effect, we must use great care and judgment, and be thoroughly familiar with every possible form of twill, and their effects when combined with each other, or we could never be certain what would follow from a combination of any two or more patterns together; in fact, our patterns would be more the result of chance than design. By the system of elongation we aim at once at a given effect; we take the surest means of attaining the object we have in view, and consequently lose little time in experiments, and leave nothing to chance. It is certainly desirable to have easy methods of working to obtain a variety of patterns, but it is quite as desirable to be able to obtain whatever result we want at once by design, and leave nothing to accident. We must study all the short methods of economising time and labour, but we must, as far as we can, be sure that the results are those for which we are seeking, otherwise it will be better for us to study the doctrine of chances instead of the principles of design.

42. **Figured Twills.**—In many cases we may desire to produce patterns having a figure running between the twill without having the pattern elongated, or without having recourse to the system of combinations. A definite result is aimed at at once; it is desired to produce a given effect without leaving anything to chance; we desire, say, to produce a pattern of the character of that shown

in Fig. 56. In this we have a decided figure running between the twill, and the angle of the twill is one of forty-five degrees. If we were to analyse this to find of what it consists, it may be said to be the result of the combination of *portions* of four distinct twills, but to attempt to produce the pattern by the system of combinations would probably be an absurdity; that is, to produce it as an original design. We might obtain what we are seeking, but again we are trusting to chance. If we wish to produce figured twills, we must proceed in a manner which will ensure what we are trying to produce. We must determine beforehand the character and proportions of the twill. We must determine also the character of the figure, and combine the two as the combination of twill and figure, not as a number of twills. Our readiest mode of working is, first to put down the twill upon paper, after we have determined its size and character, then to introduce the figure between, and continue or repeat the figure until complete. Of course the production of patterns of this class is dependent entirely upon the inventive faculties of the designer, and his ingenuity in combining two different orders of working so as to produce a harmonious whole, but there are certain rules which may assist him, and in some instances guide him. It is generally understood that variety in a design, if properly treated, may conduce to beauty. In designs for textile fabrics it is desirable in many cases not only to make the pattern continuous, but such that any repetitions of it shall not be too apparent to the eye. For instance, in making such patterns as figured twills, we should not arrange the figures in such a manner that they appear to run in straight lines, either longitudinally or transversely, in the fabric, or, to use the technical phrase, "their repeti-

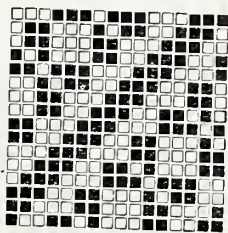


Fig. 56.

tion either in the warp or weft must not be in lines or rows." There must appear an equal and regular distribution; there must be nothing which will be too striking or attract too much attention to itself to the cost of the rest of the composition. In the pattern before us—Fig. 56—there is not much to fear on this score; it is so small, and repeated at so short intervals, that no such difficulty could arise, but in the case of large patterns it might, and even sometimes in the case of comparatively small patterns also. In such case we may resort to the plan shown in Fig. 57, where the figure is a series of steps. Now, if these steps all formed in the same horizontal or vertical line, the appearance of the pattern would certainly be unpleasant; it would simply present a series of lines straight across, or running the length of the piece, broken at regular intervals by the diagonal line; but as it is, the lines are broken by the relation of the steps to each other, and we have consequently a more harmonious diagonal. The steps in

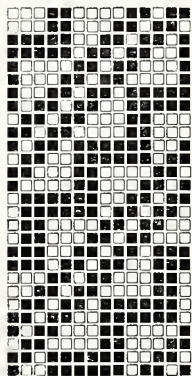


Fig. 57.

the figure do not fall either immediately under or alongside each other, consequently there is nothing to break the diagonal line. We have only given variety to it by the introduction of the waved line. The diagonal is the principal feature of the design, the figure is merely an accessory, and each plays its own proper part.

Then we must arrange such figures so that they cannot form lines, and as we have said, this is more especially necessary when dealing with large figures, because they stand out more prominently, and strike the eye more readily, and therefore any little defect or want of harmony is more apparent. But the question naturally arises, how can we ensure this? We

must, as we have said before, leave nothing to chance. The most simple and ready manner of doing this is to make the figure occupy a number of ends or picks which will not be a measure of the number occupied by the diagonal. In Fig. 57 the number occupied by the diagonal is fourteen, the number occupied by the figure is four; therefore at each repetition of the twill we do not have a repetition of the figure, but only at every alternate repetition. The variety would even be greater if the figure occupied a number which has no common measure with that of the diagonal, as, for example, the diagonal occupying fourteen, and the figure five ends, The repetition would not be so frequent; that is, the point where the twill and figure meet at the same moment would not occur so often, and consequently there would be less risk of the figure detracting from the diagonal, or breaking the line.

43. When Figured Twills are Complete.—We have only one matter now to look at in connection with this system of combining twill or diagonal patterns and figures—namely, the determining the point where the pattern is complete; and the principle which we applied to the combination of twills occupying different numbers of ends will also apply here—that is, carrying them forward to a number of which that occupied by the diagonal and the figure shall be a measure. Thus, in Fig. 57 the twill occupies fourteen ends and the figure, counted diagonally, occupies four; then the number of which fourteen and four are both a measure is twenty-eight, so that the pattern will require fourteen ends and twenty-eight picks, or *vice versa*, to complete it; had the figure occupied five ends and the diagonal still remained upon fourteen, then the number of picks required to complete the pattern would have been seventy, because that is the first number of which each is a measure.

44. Combination of Different Orders of Working in Stripe Form.—We have now one other system of

combining twills or other working for the purpose of producing patterns to consider, and in this, although the mere placing of the patterns together upon paper is much the same as some of those we have already considered, yet the conditions or characters of the combinations may be such as to completely alter the structure of the fabric and to require special consideration of the relative quantities of warp and weft in each portion of the cloth. We will, in the first place, deal with the subject in the most simple manner, by combining two patterns of the plainest character. It often happens that we desire to produce a striped effect upon a fabric having a plain ground, and we desire to make this stripe stand out as plainly and prominently as possible, whether the stripe be of the same colour as the ground or of a different colour. Or it may even be that the *material* composing the stripe is different from that of the ground, and the order of working also different. We will take, for example, Fig. 58, and suppose in the first place that we are using one colour only, and one material only, so that we may see more directly the effect upon the fabric of the different orders of interweaving. In the first place, we have a number of ends weaving quite plain, or interlacing with each other alternately. We have then a number of ends weaving in the order of a twill, or interlacing with each other at intervals of four. Now, it must be obvious that if all the warp threads of which the cloth is to be composed are of the same thickness, are set equally close together, and come from the same warp beam, so that the same length of each be given off as the fabric is formed, the portion which is weaving plain cloth, being more intimately woven with the weft, will "take up," or become much tighter than the portion which is forming twill. In addition to that, the texture of the fabric in the plain portion will be much firmer than that of the twill portion. It is a generally accepted rule that all portions of a piece of fabric should be as nearly as possible equal in firm-

ness of texture, and also that the portion which forms the ornamental part should certainly not be inferior to the ground or body of the fabric. Then we must resort to one of two expedients—either we must use thicker warp, or there must be a greater number of ends in the twill portion than in the other. If we use thicker warp simply, we increase the bulk of the fabric very much, and greatly increased bulk is objectionable. On the other hand, if we increase the number of ends simply, employing the same thickness of warp as for the ground, we again obtain increased bulk, though certainly not in the same degree as in the previous case, that is, if we bring the threads of the same weight as the ground warp sufficiently close together to make the twill portion as firm in texture as the plain, we shall not have so much weight as if we keep the number of threads in a given space, as in the ground, and increase the thickness of the threads to a sufficient extent to obtain the requisite firmness of texture, because the weight of threads does not vary in the direct ratio of their diameters, but as the squares of their diameters. This being the case, it is clearly better not to increase the weight of the threads employed in forming the stripe, but to increase the number of threads in a given space; because we not only keep nearer the weight of the ground fabric, but we increase the firmness of the stripe, and so improve the appearance. Indeed, we may go a step further, and instead of using the same thickness of thread for the stripe as for the ground of the fabric, use a much thinner thread, and increase the number again proportionately, and we shall not only be bringing the relative weight of stripe and ground nearer together, but we shall be bringing the relative firmness of structure nearer the same level, and at the same time improving the appearance of the fabric in a great degree; for in many cases, especially where only one colour is employed, the fine appearance of the stripe is the chief thing relied upon for the ornamentation. Well, suppose we don't resort

to these expedients, we must see what will be the general effect of the fabric. In the first place, as we have already pointed out, the stripe portion will be less firmly interwoven than the ground; it will consequently have a ragged, thin, and meagre appearance, and from this very thinness and looseness it will be liable to "fray," or the threads will slip upon each other, instead of being held firmly in their places. Again, it will probably present an unsatisfactory appearance from what is termed "cockling," or, in other words, one portion of the fabric will appear nice and straight, while another, the stripe portion, will be uneven and appear as a series of ridges and hollows.

Such a state of affairs could not of course be satisfactory, therefore in all such cases we must take care that the ground and stripe are properly proportioned to each other, and the relative quantities of warp and the thickness of the warp in such portion properly proportioned to the order of interweaving.

In the example (Fig. 58) we have taken the stripe as a simple twill, but very frequently the stripe is a satin, or it may be any order of working which will separate it sufficiently from the ground, and show it up with enough



Fig. 58.

prominence. It may also be not only of a different colour, but also of a different material. It is no uncommon occurrence to see the ground of the fabric formed with cotton warp and the stripe portion silk. In any case the true relations must be maintained between the stripe and the ground, and either the difference in the thickness, or the number of ends in a given space, or both, must be properly regulated to the order of interweaving, so as to secure the most perfectly balanced fabric.

In many fabrics the ground will show a predominance of weft on the surface, while the stripe shows

a predominance of warp. Here the relative quantities will require even more careful attention, though perhaps in some few instances the predominance of weft in one case will, to some extent, neutralise the predominance of warp in the other. But we have already pointed out that, in general, when the weft or the warp predominates on the surface in the order of interweaving, it should also do so in the actual number of threads employed in a given distance. In any case it is necessary that great care should be taken to make the fabric as perfect as possible.

CHAPTER V.

DOUBLE CLOTHS.

45. The Value of a Knowledge of Double Cloths.—Whilst considering the structure of fabrics, combined with their ornamentation, and before entering upon the question of ornament purely, there is one class with which we must deal—namely, double cloths. This comprises a great many of the most useful fabrics made, and enables us to produce not only an useful article, but gives us great powers of ornamentation. Another feature of much importance in double cloth is that a thorough knowledge of fabrics of this structure is perhaps the best guide to the production of fabrics of a purely ornamental character. In fact, any one who has a complete mastery of the principles of the weaving of double cloths, and the methods of ornamenting with them, need not despair for a moment of being able readily to deal with fabrics of any description. For he must not only be able to ornament his fabric, but he must be able to follow in detail every separate thread, or set of threads, and deal with each, and apply it to the purpose for which it is intended, with

a due regard to both the structure of the fabric of which this set of threads is composed and also to the order of working of the fabric and threads which may accompany it.

46. We may inquire, in the first place, *What is the object of making double cloths?* Generally speaking, we may be said to have one of two objects in view, or perhaps the two may sometimes be combined. First, we may make double cloths for the purpose of producing a fabric of great bulk and strength, and with great power of retaining warmth as an article of clothing; second, we may make double cloth for the sole purpose of producing an ornamental fabric; or we may combine the two by producing an article both useful and ornamental. In discussing this portion of the subject we must be careful to omit no detail which is likely to have a bearing upon future work; and the student must be equally careful to be thoroughly master of it before he leaves it, otherwise he may find that some of the fabrics with which he may have to deal appear quite foreign to him, based upon a principle of which he has no knowledge, whereas they may have their first basis or ground-work in double cloths, perhaps of the most simple kind. It will not be necessary here to enter too fully into the mere arrangement of the design upon paper, as that has already been done in the "Practical Treatise on Weaving and Designing," already referred to; but we must deal more especially with the structure of the cloth, and the methods of ornamenting it.

47. **Cloths with two Wefts and one Warp.**—In the first place let us consider what are commonly known as double cloths, which are made for the purpose solely of producing a heavy fabric, chiefly with a view to making a warm, useful article of clothing, and then show the application of the same mode of working for producing an ornamental as well as an useful article.

This class of what are called double cloths, is double

only in one sense—namely, there are two separate wefts, one for the formation of the wearing surface, and the other for forming the back, or, as it is sometimes and very properly called, the “lining” of the cloth, and there is only one warp. Generally speaking, the pattern on the face of the fabric is a fancy one, and that on the back of as plain a character as the structure of the cloth will permit; but sometimes, more especially when the article is intended to be reversible, both patterns are alike. In the latter case the most general practice is to make both patterns of a plain character, a simple twill or plain satin, the chief object being to cover the warp as effectively as possible, and at the same time to prevent the weft of the opposite side, which is frequently of a different colour, from showing through. We will first deal with the class where the back cloth or back weft is used merely to add to the weight, strength, or wearing qualities of the fabric, regardless of pattern. In such cases we should deal with the face fabric as regards pattern, proportion of weft to warp, and other conditions, just as if we were dealing with a single cloth. In fact, the conditions of structure must be just as if there were no probability of a back being put upon it. We must consider the back as a “lining” only. We must prevent it interfering with the face, either as regards the formation of the pattern or as affecting the relative quantities of warp and weft. The back must be merely an addition, introduced independently of the face, with a view to make the fabric serve the purpose for which it is intended more thoroughly, and must be interwoven with the warp so as substantially to form a part of the fabric, but must not, unless for some special reason such as we may have to point out, in any way interfere with the working of the face pattern.

We will take for our first illustration one of the plainest patterns possible, so as to show clearly what is meant by this system of making double cloths or

lining them. Fig. 59 is the working design for a plain twill cloth face and a back of weft upon it, such as is commonly used for cloths for gentlemen's coatings. The separate designs for face and back respectively are shown at *a* and *b*. In designing fabrics of

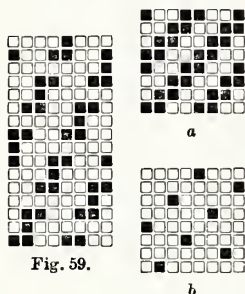


Fig. 59.

this kind these are the two chief objects—namely, the proper relation of the back to the face pattern, and the proper relation of the warp and weft which forms the face. Let us examine this pattern for the purpose of showing how we may best deal with these considerations. First, with regard to the relation of the two patterns to either. An examination of the pattern in Fig. 59 shows that it is simply

a combination of the two patterns *a* and *b*, but that combination is made in a particular manner; in fact, the two patterns are specially arranged to suit each other. We are not proceeding upon the same lines of combination as we did when we were combining merely to produce new patterns for ornamentation, but we are proceeding to combine with a specific object in view. It will be observed in the design that at the point where the back weft passes over a warp thread the same thread is also passed over by the face pick of weft which goes before as well as by that which follows the back pick; or, in other words, we have first arranged our face pattern, then introduced the weft which is to form the back or “lining,” and interwoven that back weft into the warp at a point where it is on the under side of the fabric. By this means the weft forming the back is effectively prevented from coming to the surface of the fabric; the face picks will close over it, and continue to form their own pattern as if the back had no existence. Thus we have here the first principle

of making designs for double cloths ; and, although we are speaking of one class of double cloth only, that one feature belongs to all classes. We have now to consider more in detail the arrangement of the design. It may be said that, so long as the face pattern is perfect—a regular continuous twill, or a complete pattern of any description—it matters little as to the order of binding the back weft provided it does not interfere with the face ; but in this, as in the arrangement of all designs, we must have regularity and definite order, and the order of binding the back must be arranged to suit the face pattern, so that it will always fall in the proper place. Sometimes it may be that the pattern on the back is a twill, or it may be a satin or other broken order. In the case before us we have the back pattern arranged in satin order simply as a matter of necessity, so that it shall fall always in the same position in relation to the face twill, and also so that the binding falls equally in each twill and upon every end of the pattern. It will be noticed that there is one pick of the face weft to one of the back weft ; the face pattern is a four-end twill, the weft passing over two and under two ends alternately ; the back pattern passes over one and under seven ends. The twill of the face advances one end to the right at each pick, and the back pattern advances three ends to the left or five to the right at each pick. The face twill having advanced one to the right, and being twice repeated in the whole pattern, may be said to have brought the point in the face twill corresponding to that when the first backing pick is bound, to a position three ends to the left or five ends to the right from that binding point ; consequently, if we advance three in one direction or five in the other with our binding of the back, we shall place each backing pick in the same position in relation to the face, and, as three is not a measure of eight, the result will be a perfect distribution of the binding points ; each end will be occupied. We have, therefore, a perfect pattern on the

back. Each of the face twills has an equal number of binding points, and those points always fall in the same relation to the face twills, and we have as perfect an arrangement of double cloth as it is possible to obtain. We will examine another arrangement of the same face twill with a back upon it, and then we shall be able to see more readily the defects which may occur. Take the pattern in Fig. 60. Here we have the same face pattern, but we have two picks of the face to one of the back. The pattern has, therefore, advanced two ends from the position of the first binding of the back before we come at the proper place for the binding of the next back pick, and, as two is a number which is a measure of eight, we cannot resort to the satin arrangement of the back pattern. We must, of course, keep

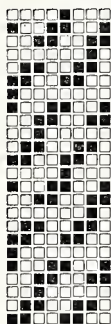


Fig. 60.

the binding in the proper position in relation to the face pattern; we must also distribute the binding equally over all the twills; therefore the arrangement shown at Fig. 60 is the only possible one. On the paper this has all the appearance of being perfect, and, perhaps, in some qualities of cloth would be so, but it is not all that could be desired, and in other fabrics may be very imperfect. It will be noticed that, in consequence of the order of arrangement of the back pattern, only every alternate end of the warp is occupied by it; and again, there is a decided twill formed by the back weft running in a direction contrary to the face twill.

If the weft used for the back happened to be very thick, more especially if at the same time that of the face was fine, not only would this counter twill be distinctly visible, but the ends passed over by the back weft would tend to work much more tightly than the others, and so produce a fabric of a most imperfect kind; in fact, it would be a quite unsaleable article, and the nature of the defect is such that it could not be remedied.

Again, in Fig. 61 we have the same face pattern, but the back is different. In this case we have the same defect of the binding only occupying every alternate end, and the twill of the back running counter to the face, or rather the appearance of a twill—it is not in reality a twill; but as the binding and this apparent twill are so much more frequent, there would probably be less of the defect visible on the face. There is, however, another matter to consider here—namely, that the binding of the back into the warp occurring at every fourth end, instead of at every eighth, as in Fig. 60, it might in some degree prevent the face weft going in so closely, and thus prevent the face from being made quite so fine in texture. In the fabrics with which we are now dealing the general practice is to make the back weft of very much coarser and heavier material than the face, the chief object being to increase weight, and to make the fabric more useful as a warm article of clothing, and at the same time to make it as cheaply as possible. It is therefore evident that great care must be taken to prevent the undue interference of the back with the face cloth, because we must make the face extremely fine, and free from faults or blemishes.



Fig. 61.

48. Pattern formed by Binding.—In some few instances the back weft is purposely brought through into the face to assist in the formation of patterns, or perhaps it would be more correct to say to form a pattern in addition to that made by the face weft. For instance, by bringing the back weft through to the face at regular intervals, and constantly upon the same end or ends, a stripe would be produced, and if to this were added one of the picks coming through in like manner all across the piece a check design would be obtained. Any pattern may be formed by bringing the back weft

through at such points as may be required for its formation.

49. Reversible Cloths.—Another most valuable use to which this class of double cloths is largely applied is the production of reversible fabrics, which may be worn on either side at will—such as shawls, rugs, a great many mantle and other cloths. Usually in fabrics of this description, the pattern upon both sides is the same, but the colours are different. Fig. 62 shows a plan of a fabric of this kind which is simply a combination of two satins, one showing a greater proportion of weft than of warp to the surface, and the other the same quantity to the back. In this it must be observed that the same principle of arrangement is carried out as in Fig. 60—namely the point where the back pick interweaves with the warp is covered on the face both by the preceding and the succeeding picks, so that there is no possible chance of its showing through to the face; and, in the same manner, the point where the face weft interweaves is hid at the back by the back weft, so that both sides shall be equally



Fig. 62.

perfect. In this class of pattern we have to consider both sides of the cloth, unlike that in which the back is simply a "lining," and the two also differ in this respect—that whereas reversible fabrics must have both sides equal in quality or degree of fineness, and generally in texture or pattern also, those which are simply backed to give weight may have the back any degree of fineness or coarseness, and the pattern may be anything which will not interfere with the face.

The colours of the weft used may be different for each side, or one side may be all of one colour and the other side any fancy stripe pattern. Generally the chief object in fabrics of this description is to make each side as different as possible from the other, whether they be both solid colours, or one side solid and the other striped, or both striped, and to ensure this distinction there must

be absolute certainty that the weft of one side cannot possibly show through to the other, and that the warp—which may be of an indifferent colour—cannot be seen on either side. If the pattern be a twill, we may prevent the wefts from showing through to the opposite sides, but we cannot prevent the warp from showing, because, the order of interweaving being consecutive, each succeeding warp thread is, as it were, laid bare, and must be visible on the surface of the fabric.

Then to cover this the usual practice is to make the pattern a satin, so that by the order of interweaving being arranged at intervals, each succeeding pick has an opportunity of covering the binding of the preceding pick, and so securing a perfectly solid surface, and avoiding the possibility of the warp showing through. Of course in such cases there can be no pattern visible, except that formed by the varying colours of weft; there is no pattern in the fabric formed by the interweaving of the warp and weft threads.

50. Figured Reversible Cloths.—Although so far we have dealt only with reversible cloths in which we are dependent entirely upon the use of colour for ornamenting, we have other means still at our disposal for producing ornamentation upon them. It has been shown that we may have a fancy pattern on one side of the cloth, and a plain or simple twill on the other, and also that in fabrics where the working or order of interweaving the warp and weft is the same on both sides, it may be reversible for wear, and each side may be of a different colour or colours. We have now to deal with the ornamentation of this latter class by figuring. This mode of figuring differs somewhat from all other systems, though to a certain extent it resembles in style one or two methods with which we shall have to deal. We have already pointed out that in making reversible cloths we use two distinct wefts, one for each side of the fabric. In making figured reversible cloths exactly the same principles are involved, only

instead of letting each weft remain always on the same side they are made to exchange places. Fig. 63 shows a section. The dots represent the warp threads just as we

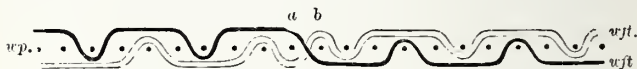


Fig. 63.

should see them if we were to cut the cloth and look at it as it has been cut, and the waved lines represent the weft, and show the order of interweaving with the warp. This section shows each weft forming a four-end twill pattern with the warp, but at the points *a* and *b* respectively the weft which has been on the face of the fabric passes to the back, and that which has been on the back comes to the face. This would be repeated at each succeeding pick, and the points where the two wefts exchange places would alter according to the pattern to be formed. So that, assuming the

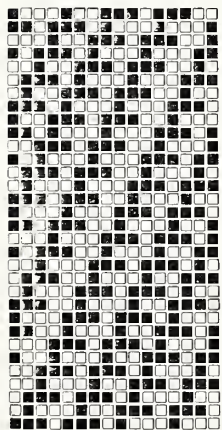


Fig. 64.

two wefts to be black and white, we should have on one side of the cloth a white ground with black figures, and upon the other side a black ground with white figures. Of course the size, form, and order of distribution of the figures would be the same upon each side, being formed as they are simply by the two wefts exchanging places. In Fig. 64 we have a plan of a pattern showing this order of working, and forming a diagonal of black and white alternately. If each pick of weft be examined, it will be seen that for a given distance each comes to the surface of the fabric and then passes to the back, and the next succeeding pick works exactly the reverse,

the point of exchanging places altering at each succeeding face pick in such a manner as to form the desired pattern.

This system of figuring may be carried to any length. There is practically no limit to the variety of patterns we may produce. They may be large or small, simple or elaborate, at will, and the fabric will always be such as can be worn on either side. It may, perhaps, be as well

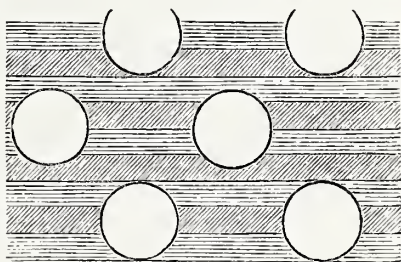


Fig. 65.

to guard the student against one possible misconception of the words we have just used as to the variety of the patterns we may produce by this mode of working. What is meant is, that patterns, or, as they are usually termed in the trade, "figures," of the most varied forms may be pro-

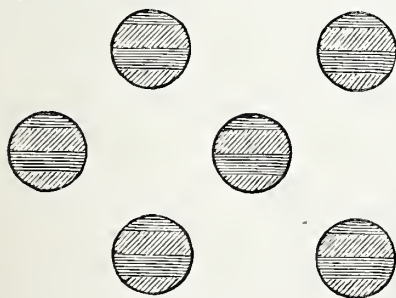


Fig. 66.

duced, but not that variety of colours may be introduced into the design. We have one colour of weft for one side, and another colour for the other side, and, as we have shown, the figure or pattern is formed by these exchanging places and occupying

alternate sides of the fabric; therefore we have one colour of ground, and a different coloured figure upon it on one side of the cloth, and exactly the reverse on the other side, so that the ground is one

solid colour, and the figure is another solid colour in each case. Sometimes a variation is made, and one side of the cloth is striped in the ground ; in that case the figure of the reverse side is striped in exactly the same manner, as shown in Figs. 65 and 66 ; but that stripe in the figure will be more likely to spoil the effect than to add to its beauty, because in all probability, if the stripe be a small one, the figure will present a quite broken-up appearance, without any order, and if the stripe be a large one, it may be divided into two portions, one of one colour and the other of the other. Those portions may be equal or unequal, and unless considerable care and skill be employed, the divisions of the colours in the various figures will be very irregular. In any case the use of varied colours in fabrics of this class must be of a more or less stiff character, partaking of the stripe form ; and where the fabric is not figured—each weft remaining on its own side—they may be used with advantage ; but when figured, the greatest care must be taken that the figures are not too much or too irregularly broken up, otherwise the effect will be very unpleasant. If the patterns be of a regular character, as a diagonal, then the use of more than one colour may be decidedly advantageous, because the pattern being continuous, the striping will occur regularly, and will be no drawback, but may rather add to the beauty and variety of the design.

Generally, any variety of colour in stripe form is confined to one side of the cloth, at any rate in figured goods, so that we have on one side a solid coloured figure on a striped ground, and on the other side a striped figure on a solid coloured ground. If both ground and figure were striped, the effect would probably be too much of a mixture, especially if the sizes of stripe in each case were similar. However, we must be guided at all times by the particular effect desired, and also by the due consideration of the purposes to which the fabric is to be applied, and suit our pattern to the requirements of the case as best we can.

51. Cloths with two Warps and one Weft.—The second class of double cloths, or what is known as double warp faced cloths, consists, as before said, of two warps and one weft, and is really the class with which we have just been dealing inverted, warp becoming weft, and weft becoming warp. The uses to which this class of fabric is put are probably much fewer than the double weft face, but still sufficient to make it well worth while for the intending designer becoming thoroughly master of the principles upon which it is based. This principle of structure is most generally applied to fabrics in which both sides are intended to be alike in pattern and quality, though they may be different in colour. The arrangement of the plan upon paper is precisely the same as for double weft face, taking weft for warp, and *vice versa*; for example: Fig. 62, if read warp for weft, would be a plan of a double warp face, as shown in Fig. 67. We need not, therefore, dwell at length upon the arrangements of the design or plan of this class of fabric, seeing that all we have said of the double weft face applies also to the double warp face, so far as it is used in practice. We must, then, apply ourselves to the consideration of the uses of double warp face to the production of useful fabrics, and see how far what we have said of double weft face is applied in practice to double warp.



Fig. 67.

It has already been pointed out that this principle of structure is most generally applied to fabrics where both sides are alike in quality and structure, as, for example, to ribbons used by ladies for trimming, when one side is of a totally different colour from the other, but both present the same fine satin appearance. In fact, it is to this class of goods more than any other that the double warp face is applied. For this reason such goods are usually made with fine silk on the surface, and in the process of weaving an immense number of threads of such fine material may be used per inch as warp. Their

very fineness, and the smooth nature of the silk thread, will not create any difficulty in the process of weaving ; and the small number of threads per inch in the opposite direction or weft enables the weaver to produce a much greater length of fabric per day than if the cloth were made on the double weft principle, where the conditions would be reversed ; but in the case of woollen-faced goods these considerations would not hold, because of the thickness and roughness of the thread, which would render it quite impossible to weave with the number per inch which would be required to produce the necessary fineness of fabric. In some few instances the use of two warps is applied to fabrics made from wool for the same purpose as the use of two wefts—namely, to obtain increased weight. In such cases the face, or fine warp, forms the fabric proper with any pattern that may be desired, and the back warp forms merely a lining of any loose pattern which will not interfere with the face. Such fabrics are not so easy to weave as if they were made with two wefts instead of two warps, because of the thickness and roughness of the threads ; but the necessity for employing two warps may often arise from the fact that our looms are not adapted to the production of double weft cloths. For instance, if our looms are constructed to weave with one shuttle only, we are only able to use one weft ; and if the material we are using for the face cloth be very fine, we cannot afford to use that for the lining also, because the cost of the cloth would be so much increased without a corresponding advantage. Then we must resort to the use of an extra warp for the back, and although we may increase the difficulties of the weaver, we shall, by the use of coarser material for the back, be enabled to produce the fabric at a cheaper rate. We may say, generally, that the use of the double warp cloth is confined chiefly to the two classes of goods we have named, being rarely used for producing figures, though perhaps in some few instances it may be so employed,

but those will, in most cases, be where the warp is silk, or very fine yarns in other materials; but the loose fibre upon yarns made from other materials than silk renders it somewhat difficult to weave with the number of threads per inch required to make the fabric sufficiently fine, even if the yarns are spun to very fine counts.

52. Two separate Cloths.—We now come to the third and most generally useful class of double cloth—namely, where there are two separate and distinct fabrics, each formed with its own weft and warp—and the consideration of the various purposes which it may serve; and we must urge the student to pay the closest attention to this class of fabric, and make himself thoroughly master of it. A complete knowledge of the two preceding classes will help him very much in understanding this class; but he must not be content with this. If he wishes to be a competent designer for fancy cloths he must study this branch until he has entirely mastered it.

To begin, let us examine the manner in which double cloths of this class are produced. In the first place, we have

a separate warp and weft for each cloth; and in making our working plan



Fig. 68.

each must be dealt with by itself, so far as pattern goes, as though the other had no existence. We have in Fig. 68 a section showing two cloths, both of which are twilled; or, rather, we show two picks (one of each cloth) which may each be taken as being the first pick of a twill, in which weft passes over and under two threads alternately. Each weft interweaves with its own warp only, and the two cloths are consequently quite independent. They are both woven at once, but the material forming each cloth is confined to that cloth alone, and takes no part in

nor combines with that forming the other cloth in any degree. The plan of this cloth is shown in Fig. 69. In it the first, third, fifth, and seventh ends and picks are those which are to form the face, or upper cloth, and the second, fourth, sixth, and eighth ends and picks are those which are to make the back or lower

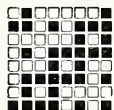


Fig. 69.

cloth. Now, if the dots upon those ends and picks which are to form the face cloth be examined, it will be seen that they make a regular twill, and those dots which are upon the back ends and picks *only* also form a regular twill; but upon those picks of weft which are to form the face cloth dots are placed at the point where they intersect the *warp threads of the back cloth*. In all cases we are assuming that those dots represent weft as passing over warp. That being so, it will at once be seen that the face weft passes clear over *every* end of the back cloth; and in like manner the weft of the back cloth passes under *every* end of the face cloth, so that each weft interweaves with its own warp only, each warp being kept out of the way—lifted up or left down, as the case may require—while the weft of the other cloth is being inserted. Then, in arranging the plans for two separate cloths, this is the principle upon which we must proceed: first put the face-cloth pattern upon those ends and picks which are to form that cloth, then do the same with the back cloth, and next arrange that as each pick of weft is inserted they interweave with the warp of the cloth to which they belong *only*.

53. Relation of the two Cloths to each Other.—So far as the arrangement of the plan of the fabric is concerned, the foregoing is perhaps sufficient to indicate the general mode of procedure, but we have now to consider the relation of the two cloths to each other. Double cloths of this class are capable of a great variety of arrangements, but they may be classed generally under four distinct heads: first, when the two cloths are

equal in quality and pattern ; second, when they differ in pattern only ; third, when they differ in quality only ; and fourth, when they differ in both quality and pattern. Of those in use, it may be said that the first and fourth of the above are by far the most general, and, as we shall proceed to show, for quite sufficient reasons.

In considering each of these four types of double cloths one question must be kept constantly before us—namely, the relations of the warp to the weft and to the pattern. It must be evident if the two cloths are equal in quality and pattern, the “take up,” or shrinkage of both will be equal, both in the warp and weft, but if they are equal in quality and different in pattern, should one pattern interweave more loosely than the other, the “take up” of one will be greater than of the other, and if they are bound together in the process of weaving, that which works most loosely will be liable to “cockle” on the surface. Perhaps it may be done for a purpose ; if so, well and good, but generally it is desired to obviate such an effect and make the surface of the cloth as smooth as possible ; in fact, to give it all the appearance of a single cloth. In that case the greatest care must be taken to make the cloths equal, and if they *must* for any reason differ either in quality or pattern, every precaution must be observed to ensure the “take up” being equal in both. Or, if the two cloths be made from materials which possess in a different degree shrinking properties, and which may be differently affected in the process of finishing the goods, then they must be made to neutralise each other, or some influence must be brought to bear which will neutralise them in the fullest extent.

We will first deal with cloths which are equal both in quality and pattern. Such cloths are usually made for the same reason as some of the double weft face cloths, namely, to produce greater weight, or to make the fabric reversible—more generally the latter ; and in

such cases the two fabrics, though equal in all other respects, will be different in colour, or one may be a solid colour, and the other a stripe or check. In any case the same principle of making the plan is carried out as has been already indicated in Fig. 69, the warp and weft of each cloth being arranged alternately, end and end or pick and pick, and each weft interweaving only with its own warp.

54. Binding Double Cloths.—Cloths of this description have usually to be bound together, so as to make them appear as one cloth, and in fact to become one cloth. In such cases the warp of one has to interweave in a greater or less degree with the weft of the other; but this must be done so as not to interfere with the pattern of either, and if the two are of different colours, they must not show through each other at the point of binding. This being so we must select a point where the weft of one cloth and the warp of the other meet, if possible at a point where one or both are interweaving very loosely, so that there will be no probability of the two being so intimately interwoven as to show one cloth through the surface of the other.

Again, we must consider whether we desire to produce in the cloth a feeling of firmness of texture or otherwise. If we want the cloth to be of a firm texture, we must bind the two separate parts very frequently and intimately; if we want softness and looseness, we must bind them only as often as will hold the two together, and no more. This knowledge of the frequency or firmness of the binding can of course only be gained by actual practice, combined with a knowledge of what is wanted in respect to looseness or firmness of texture; but no matter whether the binding be frequent or otherwise, the same principle will hold good as to the selection of the point where the binding shall take place.

55. Relation of the Pattern of each Cloth to Facilitate Binding.—In making the selection of the

point of binding, it is often necessary to consider the relations of the patterns of the two cloths to each other, so that the weft of one and the warp of the other may be brought into such a position that they can be interwoven in the readiest and the most perfect manner. The surest method of working is to make a section first of the two patterns, and place the two sections together so that the weft of one cloth at some point where it is interweaving loosely will be immediately above or below the warp of the other at a point where it also is interweaving loosely, and by that means the designer can see at a glance the best relation of the two patterns so as to secure the best binding place.

56. Figuring with two Cloths.—The most useful purpose to which double cloths of this class can be applied is in the production of figured goods, the figuring being obtained by the two cloths exchanging places, in a similar manner to the weft exchanging places in double weft face goods. And there is this decided advantage in figuring with two separate cloths which are equal in structure—that each may be either perfectly plain or of any texture which may be desired ; and if the weft of each be of the same colour as the warp with which it is interwoven, we shall have a perfectly solid coloured figure upon an equally solid ground.

Figuring with two separate cloths of this description is practised in the production of a very large variety of fabrics, and in all cases the results are most satisfactory ; for we have not only a strong fabric, but a very warm one, and one also capable of resisting both strain and friction. These advantages, coupled with that of great facilities for ornamentation, make it a most useful class, and one which may be resorted to for a variety of purposes.

57. Cloths of the same Quality but different Patterns.—We must now turn our attention to the

second of the four classes—namely, those in which the fabrics differ in pattern but remain of the same quality. In the use of the term “same quality” it must be distinctly understood that we simply refer to the number of threads per inch of both weft and warp, the thickness of the yarn being exactly the same in both cloths, and not to the quality of the fabric as it will be affected by the structure or order of weaving. It must



Fig. 70.

be our object to show that where two cloths which are woven together are made from the same material, it

requires the greatest possible care to insure the quality of the two being the same in texture as well as in the material from which they are made. The pattern of each cloth must be so arranged as to secure this, otherwise the fabrics will not be perfect.

We will begin, for example, with an illustration of the simplest kind, and combine two patterns which are probably more known and used than any other—that is, a four-end twill and a plain cloth, as in Figs. 70 and 71. Suppose we are weaving two cloths together, one of which is plain and the other the twill given here, and that the threads per inch both in warp and weft, and the thickness of these threads, are the same in both. The two could not be equal in texture. One would be much firmer than the other; they could not both be equally perfect in structure. If the quantity or thickness of the material be arranged to suit one of the patterns and to make it a perfect fabric, it could not make the other equally perfect. Perhaps a medium might be found—the plain cloth made heavier and firmer than it should be, and the twill lighter and looser, so that neither should be so far removed from a true and perfect structure as to be so imperfect as to be objection-



Fig. 71.

able ; and, at the same time, the two might be so intimately bound together that the plain or stronger fabric would support, and to some extent improve, the strength and quality of the twill cloth. Still, with all these precautions, there would be danger of the fabric being imperfect. In the process of weaving the plain cloth would work very tight and firm, and would require a greater length of warp to make a given length of cloth. Again, not only will there be more shrinkage in the warp (which may be overcome by letting the two warps come from different warp-beams), but there will be more shrinkage in the weft, because of its having to bend more round the warp threads in a plain cloth than in a twill. In some cases, perhaps, this may be advantageous, because if the two cloths are sufficiently bound together it will in its shrinkage carry the twill cloth with it, and so give greater roundness to the twill. On the other hand, if the fabric has to undergo a process of finishing, which will cause shrinkage, the twill cloth, because of the very looseness of the threads, will be liable to shrink more in the finishing than the plain one, and so counteract its influence. But in fabrics of this description the two must be bound together very closely. It is difficult to estimate the exact amount of shrinkage which is likely to take place relatively in the two cloths, and more especially if the process of finishing be a severe one, or if the material be of a nature which will assist the shrinkage, as, for instance, in woollen cloths which are milled. If, in such cases, the two cloths are too loosely bound together, or the points of binding are too far apart, that which shrinks most, even if it be only in a slight degree, will cause the other one to form bubbles, or "cockle," and so give a most unsatisfactory appearance to the whole.

It is even more difficult to deal with fabrics of this class if we attempt to figure with them in the same manner as when the two cloths are equal in quality and texture, because usually in figured double cloths there

is no binding introduced, except where the two cloths intersect each other. Consequently, if one should shrink more than the other, the "cockles" or bubbles would exactly correspond with the figure. There are double cloths where an effect similar to this is aimed at, but in such we must adopt means which will ensure the evenness and regularity of the embossed character which it will present; we must not trust to chance, or the possibility of the effect being produced by one shrinking more than another. It may be all very well to rely upon it to some extent, but we must not do so too much, otherwise we shall probably be often disappointed.

It will readily be seen that the combination of two cloths of the same quality, so far as the number of threads per inch and thickness of these threads is concerned, but of different patterns, is not a desirable thing to practise, unless for some specific purpose; and even when resorted to great care and skill must be exercised to secure the proper result. Sometimes, perhaps, it may be necessary, but it is well to avoid it as far as possible, and where it must be employed, let the conditions be examined with the greatest care, otherwise disappointment will be sure to follow.

58. Cloths of the same Pattern, but different in Quality.—What has been said of cloths which are of the same quality but differ in pattern will apply practically to cloths which are of the same pattern but differ in quality. For instance: if we make two cloths together in the same loom, both of the same pattern, and both having the same number of threads per inch, but the threads of one cloth of a different thickness from those of the other, the two cannot possibly work well together, or assimilate; and it is an imperative condition in nearly all double cloths that the two must assimilate and combine to form the same fabric; but if one be very fine, and the other be very coarse, this is scarcely possible.

It may be said, if we combine two cloths of the same pattern, each composed of threads of different

thicknesses, we may vary the number of threads so as to compensate for the difference in thickness. That is perfectly true; but there must be some harmony between the relative number of threads in each cloth. Suppose, for example, one had, say, sixty threads per inch, whilst the other had eighty-five, there would be a difficulty in weaving. In the first place, they could not be arranged satisfactorily in the reed, nor could the weaver arrange the succession of the picks in any definite order without an immense amount of labour. The points of binding the two together would be ever varying in relation to the pattern, and altogether there would be endless confusion in the work. To weave double cloths satisfactorily it is imperative that there must be regular order of succession of the threads of both warp and weft; that is, they must be alternate, or two of one cloth to one of the other, or some such order. Then it follows that if the patterns be equal, and the threads are alternate, the diameters of the threads must be equal. If the patterns be equal, and the order of succession or proportion of threads in one cloth be two to one, then the diameter of the threads must bear the same relation to each other; and whatever the proportion of threads in one cloth be to the threads of the other, their diameters must bear the same relation. Fabrics of this description are often made, but unfortunately the true ratio of the threads per inch and their diameter are not always considered, and even if they are, they are in many cases considered upon a false basis, the designer proceeding upon the assumption that the diameters of threads vary in the direct ratio of their weights, instead of the ratio of the square root of their weights. This false assumption is probably a greater source of trouble to the makers of double cloths of all descriptions than anything else. No matter what may be the character of the fabric, the true ratio of the diameter should never be lost sight of from first to last.

Cloths of this class are frequently used, more especially where it is desired to have a heavy, strong fabric with a very fine surface. The face may be made as fine and the back as coarse and heavy as we please, so long as we preserve the proper proportion between the two; in fact, the back becomes simply a "lining," something to give weight and strength. Fabrics of the most beautiful texture on the face, and yet of a very heavy, useful character, may be made upon this principle, and it is capable of application in a great many ways. At the same time, although the texture may be varied, the patterns are not much varied in cloths of this class, but are confined chiefly to plain or simple twills, for the reason that it would be absurd to make the back pattern a fancy one, when it is intended only as a lining.

59. Cloths where both Quality and Pattern are Different.—If we wish to produce a fabric with a fancy face, and gain weight and strength by putting in a lining, we must resort to the fourth class of double cloths, where pattern and quality are both different. Here we have at command all the capacity of ornamentation which single cloths give, combined with the means of obtaining weight and strength, by the use of double cloths. Double cloths of this type are perhaps more used than any other. Throughout the woollen trade, in making cloths for men's wear, they are almost universal, and in many other branches they are also largely used. Generally such cloths are made with some fancy pattern on the face fabric—fancy, not only in the order of interweaving, but also by the use of colour—while the back cloth is either a perfectly plain one or a simple twill. The face cloth is usually very fine, made from fine material, while the back is coarse and heavy. Of course the face cloth may be made as elaborate as possible, and the back as plain as possible; in fact, the plainer the back, provided it will admit of a sufficient quantity of material being put in, the better, because

the plainness adds to the strength by the warp and weft being so intimately interwoven.

The arrangement of the pattern on paper for this class of fabric is, of course, precisely the same as for cloths which are equal in both quality and pattern, only instead of the threads of warp and weft being alternate, they will generally be two of face to one of back, or in such proportion as is required to give the proper weight or thickness of cloth, or to produce any desired effect.

In making double cloths of this class the cultivation of the habit of dealing with each independently of the other is of the greatest value, so that the designer may know exactly what is the structure of each, and be able to see what is the pattern upon it at a glance; he can then compare their relative orders of working, and select his binding places with certainty. Of course the same principle of binding must be followed in this class of cloth as in the preceding, but in many cases there is much greater difficulty of binding than in the others. In the first place, the difference in the quality and thickness of the yarns makes it necessary to select binding places where there can be no risk of their showing through to the face; and it is most advisable, to assist perfect binding, to select the two thinnest materials; for example: if the back cloth be a very coarse, heavy one, in most cases the weft will be thicker than the warp, and the back weft will certainly be thicker than the face weft; so that it would be very desirable, in such a case, to bind the two together by lifting a back warp thread, and allowing a face weft thread to pass under it. Of course this must be done in accordance with the rule mentioned for binding two equal cloths together—namely, that the back warp must be on the upper side of the back cloth, or next the face cloth, and the face weft must be on the under side of its cloth, so that neither is drawn out of its regular course more than the mere thickness of the thread.

Then the second, and in many instances the greatest, difficulty arises from the relation of the two twills to each other. If the two patterns, for example, occupy such a number of ends each that they are not both complete at the same time, or, in other words, that the number of ends occupied by the back pattern is not a measure of the number occupied by the face, then at every repetition of the face pattern the back will fall in a different position in relation to it, and a binding place selected at one point which might be perfect would be entirely wrong at the next repetition of the pattern. We will take, for example, a ten-end pattern for the face and a four-end pattern for the back, and make a section as shown in Fig. 72.

This pattern cannot be complete until twenty ends of each are gone over, because that is the first number of which ten and four are both a measure. Had the relative quanti-

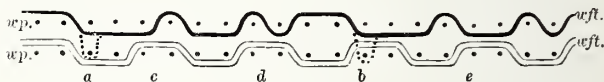


Fig. 72.

ties of face and back cloth threads been two to one, then it would have required forty threads of face and twenty of back to complete it, and consequently the difficulty of binding would have been greater. However, we will examine the binding of this pattern. We have selected our first binding point at *a*; the next repetition of the face pattern is at *b*, but if we bind at *b* we are not taking an end from the back twill corresponding to that we have taken at *a*, and if the binding at *a* is perfect that at *b* cannot be.

Again, if we take every corresponding end of the back twill, they will fall at *c*, *d*, and *e*. Now, every one of these points occupies different positions in relation to the face twill, and if the weft be brought from the face under the back at these points, some of them would be

very imperfect. Take, for instance, the point *d*, where we should have to bring the face weft through its own warp to bind under the back end. Instead of weft of one cloth and warp of the other being together, we have the warp of both cloths together, the weft of one cloth above and that of the other cloth below them, so that it would be quite impossible to bind them perfectly at such a point. It will be obvious that nothing but great care in selecting the points at which the binding is to take place, and in arranging the relation of the two patterns to each other so as to facilitate this selection, can ensure perfect fabrics, more especially when the two patterns occupy different numbers of ends, and fall in different positions in relation to each other in consequence. Of course, having found one or two places where binding can take place if the two patterns run concurrently, as they very frequently do, there would be no further trouble. We can bind as often as we please simply by following up the line of pattern, and always binding at corresponding points. Sometimes, though, we are debarred from this, and we have another kind of difficulty presented to us. Suppose we have on the face a fancy twill running, say, in a vertical direction up the fabric, one which may be the result of the combination of two or more twills, or simply produced by the process of elongation, as, for instance, in Fig. 49 or Fig. 55, and we are putting a back cloth of an ordinary twill along with it. The two patterns running at different angles, we should have to find fresh binding places at every point where we wish to bind. Because of the different angles, the two patterns could not occupy the same position in relation to each other at any two points, except at such distances apart, determined by the repetitions of the back pattern bringing it into concurrence with the face, as would probably be too great for binding purposes. At any rate we can never deal with the binding of such patterns in the same easy manner as we can where the two twills run concurrently. When we are using such patterns as this

for the face it is generally better, if we can, to use a plain back, not only because of the binding, but quite as much because the different angle of the two twills may make one cloth draw the other a little out of its proper place, and so cause "cockling." We cannot always use a plain cloth, perhaps, because of the weight of fabric we wish to obtain, but we should do so wherever we can, and avoid whenever possible—and it is possible in most cases—the combination of two twills which do not run at the same angle.

60. Forming Patterns on Double Cloths by Binding.—The binding of double cloths may be used for the purpose of producing patterns; and in certain classes of goods with which we shall presently have to deal the whole of the figuring is produced by binding, but in considering the subject generally we may point out how the figure may be most effectively produced. Of course such patterns are obtained by binding the two cloths together as firmly as possible all round the outline of the figure; for instance, if we wish to make a check pattern upon a cloth by binding, as is frequently done in worsted coatings, and also in many woollen goods. Along the line of the check, both warp and weft way, we make the two cloths become one, not at intervals, as in ordinary binding, but throughout the length of the piece upon the warp threads, and across the piece upon the weft threads, which mark the line of the check. These patterns may be made as fanciful as we please, but generally in the cloths we have named they are confined to stripe or check form.

61. Relations of Face to Back Cloth in both Quality and Pattern.—Before we enter into the question of the application of double cloth to particular fabrics, we must consider the relation of the back to the face cloth in all its aspects. We have already examined the relation of the two cloths to each other when they differ in pattern only, and when they are the same in pattern but differ in quality. We must now proceed

to the examination of those which differ both in quality and pattern. As has been already pointed out, the fabrics which differ in both quality and pattern are far more numerous than the other classes; and we may say that it almost necessarily is the case, for if we are making a fancy fabric, and putting a back cloth upon it which is intended merely for a lining, we usually make the lining as simple a pattern and as cheap a fabric as possible. As a matter of course, the face cloth—that which is to be seen, and which is to be the wearing surface—must receive the first attention. We must make that not only a fancy fabric in the great majority of cases, but we must make it as unexceptionable as we can. It must be what is termed a well-balanced cloth, perfect in structure. The relative quantities of warp and weft must be properly apportioned according to the pattern, and, in fact, every care taken that it is treated properly, as if it were a single cloth. We must then consider the back. Usually, as we have seen, the back cloth may be made as plain as possible, and if not actually a plain cloth, it must be a twill of the simplest character, and only just sufficiently loose in its order of working to permit of the quantity of material being put in to give the required weight. It too often happens that the pattern of the back or the thickness of the threads are determined by arbitrary rules, or perhaps more frequently by guess-work, or “rule of thumb.” Now, if the two fabrics are to be perfect, and neither cloth to interfere with the other, as we have shown they may do, they must both be constructed equally firm. Not that the back cloth must be as fine as the face, or that the pattern must be in the same order of interweaving, but that the thickness of the yarn and the ends per inch must be suited to the pattern in one cloth as perfectly as it is in the other. The quantity of material in one must not be such as to make a firm, stiff fabric with the pattern in which it is being woven, while that in the other is making a loose.

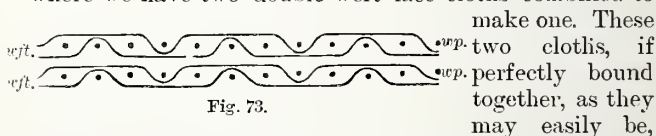
flabby article ; they must be as nearly equal as possible. If the face cloth has two threads of warp and weft to one of the back, it does not necessarily follow that the weight of the back threads is double the weight of those forming the face ; but we must take first their relative diameters into account, and then the relative order of interweaving. Suppose, for instance, we determine that the back shall be a plain cloth, and the face a twill, say a four-end twill, two weft and two warp on the surface, and that we have two threads of face cloth to one of back, both in weft and warp,—the question will be, what should be the relative thickness of the face and back threads to produce a perfect cloth, and one in which the two are alike perfect. Now, although in both patterns weft and warp on the surface of their respective cloths are equal, yet the order of interweaving is not equal ; the twill will be a much looser fabric than the plain. Therefore, although the number of threads is as two to one, the diameters of the threads must not be in the same ratio, but we must take into account the order of interweaving, which in the twill to the plain will be as six is to eight, the number of ends of face to back, which is as two to one, and the diameter of the threads, which are to each other as the square root of their counts. We shall then make each cloth equally perfect ; the “take up” of one will be equal to that of the other, and there will be no fear of one acting upon the other, and so affecting its appearance. Well, it may be said, “in practice we cannot take all these things into account ; we are working upon certain counts of yarn, and we cannot alter exactly to suit any fancy system of calculation of this kind.” The only answer is, “Then your fabrics cannot be perfect.” Very frequently fabrics are made without any previous calculation of the relative thickness of the two sets of threads, and they come up so nearly perfect that they pass as such ; but in these cases the maker is guided entirely by previous knowledge of fabrics which have been

made, and which are approximately perfect, and using this previous knowledge he may again arrive at something sufficiently near perfection; but that is not quite enough, for he may have to make a number of experiments, waste time, labour, and material, and in the end his results are only *approximately* true, whereas a proper consideration of the condition will give him with certainty the proper counts of the material for one cloth to make it perfect in its relations to the other.

So far we have been speaking on the assumption that the weft in each cloth is equal to its own warp, but frequently the warp and weft may be very different. In the face cloth this may be governed by the pattern, as was pointed out in dealing with single cloths, and in the back cloth it may be governed by questions of economy. Perhaps, in some cases, although the warp threads are as two to one in the two cloths respectively, the character of the patterns may render it necessary that the wefts may be in different proportions. Again, it may be that our back warp must be of cotton and the weft of woollen, then the weft would be much thicker than the warp; yet we must not lose sight of the proper relation of that weft to the face weft, and to the order of interweaving, and so keep our two cloths as perfect as possible in their relations to each other. If any difference does exist between the two cloths, generally the back one should be the looser and softer. Serving as it does the purpose of a lining, we can afford to have a greater degree of looseness and softness in it than we can usually in the face, because the face has to be subjected to wear, to friction, and in a great measure to strain, which does not fall upon the back, and any liability to "cockling" is far less objectionable in the back cloth, which is never seen in wearing, than in the face cloth. However, this difference must not be too great; it must not be such as to be very perceptible either to the eye or the touch, and more especially in cloth such as woollen—a material in which this class of fabric is more

made than in any other—where a process of milling or felting has to be undergone. In some cases this increased softness of one cloth may be an advantage: it will give more elasticity to the cloth as a whole, and make the face cloth assert itself more, and consequently show to better advantage; but it must not be carried too far, whatever degree of softness be given to it: it must not be much looser than the face, else the advantage gained by increased elasticity will be more than counteracted by excessive looseness and loss of wearing power.

62. Three and Four "Ply" Cloths.—In addition to double cloths pure and simple, there are many others known as "three ply," "four ply," &c., implying that the cloth is not merely a double but a three or four-fold cloth. It does not always follow though that a three or four ply cloth means that there are three or four distinct fabrics woven together, though that may be so; there may be two perfect and complete cloths, and a filling between them which is not in itself, strictly speaking, a complete cloth. Or it may be that we combine two double-faced cloths, as, for instance, is the case with some very thick bulky cloths which are used for covering rollers and other purposes. A section of a cloth of this kind is shown in Fig. 73,



make one. These two cloths, if perfectly bound together, as they may easily be, make an immense thick bulky fabric; in fact, when milled, if the proper thickness of threads be employed in their manufacture, they will present a section fully a quarter of an inch in thickness. This in common speech would be styled a four ply cloth, and may be so called with a certain amount of propriety, because each of the cloths of which it is composed is a

double-faced cloth; there are only two warps, but there are four wefts, and the manner in which these weft threads are interwoven with their respective warps allows the whole four to go into the space of one in an ordinary single cloth. This is one of the most simple applications of the three or four ply cloths, but it will help us to understand how the multiplication of cloths will enable us to produce fabrics of any bulk. Of course the principle of structure is exactly the same as in a pure double cloth. We have only to consider how many warps and wefts we have, and deal with each independently, as a weft or warp; but in combining we must consider its relation to the other wefts or warps, or the other cloths, so that they can be bound together in the most perfect manner, and so that each cloth, although bound to another, is still a cloth in itself.

It would be an easy matter to multiply illustrations, and perhaps by doing so we might add force to the one object we have in view—namely, urging the student to practise the consideration of all the individual threads which go to form a fabric, and to classify them, and consider them, in the first place at any rate, as being there for one specific purpose, and that they form part of a whole for that purpose only.

So that we may be able to do this more completely, and to prepare for the consideration of other fabrics in a more thorough manner, we will examine some of the applications of double cloths as they are generally used and applied to fabrics which come under the almost daily notice of every one, whether engaged in the textile trades or not. If we can direct the attention of the student to objects which are daily before his eyes, but of which, perhaps, he takes little or no notice, we shall probably do more to educate him than by any amount of rules or definitions. He will examine and think for himself, he will begin to inquire the reason, and in many cases he will familiarise himself with the principle of the structure of fabrics, which in after-

life he may apply to goods of a totally different character. It is not sufficient for the designer or manufacturer of textile fabrics to know merely the structure of some particular class in which he is immediately engaged ; he should have a general, and, as far as possible, a particular knowledge of the structure of other classes of fabrics, so that he may import new ideas into his own branch of industry ; and it is for this reason that we lay so much stress upon a complete knowledge of double cloths, because it will be found to be the keystone of a vast variety of fabrics to which, at first sight, perhaps, it has no relationship.

63. Scottish or Kidderminster Carpets.—One of the most largely manufactured class of fabrics to which double cloth is applied, is what are known as Scottish or Kidderminster carpets, which consist of simply two separate cloths of the same texture but of different colours. These cloths exchange places so as to form figures or patterns. In many of these carpets great variety of colours is employed, and patterns of the most elaborate description produced, but a careful examination of them will show the student that each cloth remains to itself throughout. They exchange places to form patterns, but each weft weaves into its own warp. This is one of the simplest forms of application of double cloth to figuring. The fabrics may sometimes be made three or four ply, and the figures be of the most elaborate character, yet the application of the principle of double cloth is extremely simple.

64. Quilts.—Another large class of fabrics made as double cloths, and one in which the most elaborate patterns are produced, although no colour is employed, the articles being white only, is what are generally known by the name “quilts,” which includes coverlets for beds, and also toilet covers and other such articles. These goods are usually of that class of double cloths which are equal in pattern but different in quality.

Usually both cloths are quite plain, but the face is very much finer than the back, and in some of the commoner qualities, which are known as "mock," or imitation quilts, there is no back warp but only weft. The system or mode of producing figures in this class of fabrics is very different from that of other double cloths of which we have spoken; though it is in effect the same as that mentioned in connection with coating cloths in section 60.

So as to deal in the most complete manner with this important class of fabrics, it will perhaps be as well to begin with an examination of the best qualities, and show the mode of producing patterns, then the other and inferior qualities will be more readily understood, and a more comprehensive knowledge obtained of the whole system.

Quilts of the best quality may in one sense be called three ply cloths, though there are not three distinct and perfect cloths, but two cloths and a "wadding." That is, there are two distinct and perfect plain cloths, and a loose weft inserted between them, which not only gives bulk to the fabric but assists in producing that embossed effect which is peculiar to this class of fabric. The section (Fig.

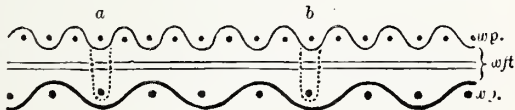


Fig. 74.

74) will explain most readily how the cloth is constructed and the figure produced. There is a fine face cloth, represented by the thin lines and dots; a back cloth, represented by the thick lines and dots; and the wadding, represented by the double straight lines. It will be seen that the face and back cloths are both perfectly plain, and the wadding pick passes clear between them. The manner in which the figure is produced is by binding the two cloths together, as shown at the points *a* and *b*, all round the outline of the figure. By binding the

cloths together in this manner, with the wadding weft between them, the figure is raised, and so produces the embossed effect. This is easily accounted for, because at the point of binding the two cloths become one, and so compress the wadding weft between them, while in the body of the figure the two are quite loose from each other, and the wadding loose between them ; so that the latter pushes the cloths apart, and of course the larger and more loose the figures, the more this will take place. Fabrics produced upon this principle not only give wide scope for producing very elaborate designs, but they also give a very substantial useful fabric. From the fact of the cloths both being plain, the strength is all that could be desired, and the wadding gives warmth. In this case the back cloth, of course, is a lining only ; in fact, the whole structure is as if we had taken two separate cloths, laid one upon the other with a thick wadding material between them, and then with a needle stitched through the whole mass all round the outline of the pattern, so as to bind them firmly together. It is very obvious that the drawing of the two cloths together with the stitching, leaving the body of the figure without any stitching, will produce an embossed effect, and the thicker the wadding and the larger the figure, the more roundness we give to it. The structure of this cloth is just as if we had done so, the only difference being that instead of using the needle, the cloths are bound together in the process of weaving, and by the threads of which the cloth is composed.

In many of the lighter fabrics of this class no wadding weft at all is used, but simply the two cloths, and more effect is given to the figure by the two cloths becoming one where no figure is being formed.

By this means pretty much the same effect is produced as if wadding were used ; though of course the figures do not stand out quite so prominently as if wadded, nor is the cloth so stout and bulky ; yet the very flatness of the ground where the two cloths form

one gives more prominence to the figure than would be expected. A section of a cloth figured in this manner is given in Fig. 75. Even more prominence will be given to it by the weft of the back cloth being thick like wadding, and by allowing, at the back of the figure which is to be most raised, the back material to be quite loose; the weft, which may be called wadding, lying loosely between the plain face cloth and the loose back warp, the latter having no weft interwoven with it at this point. In fact, the great majority of common toilet articles seem to be made after this latter method. Again, a similar effect may be produced by using backing weft only, and



Fig. 75.

letting it interweave into the ground, so as to form a thick cloth, and then pass loosely behind the figure in the same manner as the foregoing, only that there is no back warp. By this method the figures are not quite so clearly defined, and the embossed effect is not quite so good. However, by any of the three methods we have a ready means of producing most elaborate patterns without the use of colour, and the patterns may partake of any character; they need not be of the stiff type, as stripes, checks, diamonds, &c., but they may be floral, or in fact of any style which the requirements of the cloth for the purpose to which it is to be applied, or the fancy of the designers may call forth.

65. Matelasses.—Another class of fabric which has been largely used within the last few years may be said to belong to the same family as quilts, though the material of which it is made is different, and there is also more ornamentation on the face cloth. These fabrics are chiefly used for ladies' jacket or mantle cloths, and are known as "matelasses." The face cloth is

generally silk or fine worsted ; the back cloth woollen and cotton, or all cotton, according to the quality of the goods. The principle of structure is precisely the same as in the best quality of quilts. The face and back are two separate cloths, and there is a wadding weft. The figure is produced by the binding of the two cloths together in exactly the same manner as in quilts, but in addition to the figuring by binding, greater effect is given to it by varying the working of the face cloth by twilling and otherwise, so that the cloth is ornamented to the utmost, and also gives a thick useful fabric. In this, of course, the pattern may be of any character, and more effect be given to floral designs, especially by the twilling, &c., on the face than can be given in quilts when the cloth is quite plain. This system of figuring is, of course, applicable to many other fabrics ; we have merely selected these two for illustration, because more complete and perfect representatives of their class than any of the others.

66. Woven "Tucks," &c.—To enumerate all the applications of double cloths would be a difficult task. We might point to the weaving of hose, which is made as a double cloth, and many others, but we should be occupying space needlessly. However, we may refer to one or two other forms of application of a more or less novel kind ; for instance, the weaving of "tucks" for children's dress skirts, a section of which is shown in Fig. 76. To make these tucks, all the warp forms one solid fabric for the ground, then



Fig. 76.

when the tuck is to be formed, every alternate warp end only is used until a sufficient length has been woven. The warp is brought off two

beams, and as soon as the tuck has been woven the warp of which it is formed is let forward, and the tuck pressed forward by the reed, or, what is equivalent, the ground cloth is let back up to the reed, until the

edge of the tuck and the point where it commenced being formed are brought together, then the whole warp again begins to form one solid fabric, leaving the tuck as a protuberance on its surface. This operation is repeated at intervals, greater or less according to the size of tuck or their distances apart.

67. Grooves in Cloth.—Fabrics are sometimes woven with grooves in them for various purposes, the grooves being formed by weaving two separate cloths for a given distance, then combining them so as to form one cloth only. The section would be similar to that shown in Fig. 75, except that the grooves would be straight across the piece. Then the woven “ladder-tapes” for Venetian window-blinds are made upon the same principle, the narrow cross-pieces entering the body of each separate tape alternately.

68. The Ornamentation and Uses of Double Cloth.—We have now gone pretty fully over the principles of double cloth making, and examined the advantages to be gained in increased weight of fabric—strength, and warmth—as well as the various methods of ornamentation which it places within our reach. We may ornament one of the cloths only, and use the second only as a lining; we may bind the lining into the face cloth in such manner as to produce additional patterns; or we may cause the two cloths to exchange places for the production of figures, and have by that means a solid coloured figure upon a ground of another colour. These are the chief features of double cloth, but in their application there is no limit to the varieties.

A thorough knowledge, however, of the manufacture of double cloths in all the varieties of form or combination, is not only valuable as giving the power of producing a great variety of fabrics more or less heavy, but we can constantly apply it to fabrics which do not come strictly under the head of double cloths, but which are rather more for the purpose of ornamenting single cloths by the introduction of material which is used for figuring only,

and which form more or less of a double cloth only at the point where the figuring comes in.

Before leaving this subject we might briefly point out generally the classes of fabric to which the various classes of double cloth weaving are most applied. In the first place, there are those which consist of one warp and two wefts, used chiefly for woollen goods, such as union shawls, mantle cloths, rugs, coating cloths, and other heavy fabrics. Secondly, there are those which consist of two warps and one weft: applied to silks, ribbons, a few coating cloths, but mostly to fine material where a great many threads per inch in the warp can be used without difficulty. And thirdly, there are those which are two separate cloths: applied to heavy shawls, carpets, quilts, heavy coating cloths, and heavy goods generally, whether of an extreme fancy character or where plain texture is required.

CHAPTER VI.

FIGURED CLOTHS.

69. Forming Patterns upon the Fabric.—We have in the previous chapters dealt chiefly with the structure of the fabrics and the consideration of ornamenting in the structure, with the view of rather adding to than detracting from its usefulness. Of course, as we pointed out in the first chapter, we must at all times have the application of the fabric before us; yet we may determine the general structure first, and then the question of ornamentation separately. As we have dealt with the question up to this point, we have kept the two strictly together. We may now begin to consider the question of ornamentation from a somewhat different standpoint. We have to deal with pattern of a more elaborate character and its application to fabric, and make

structure of cloth subservient to design rather than design subservient to structure, at least so far as the question of usefulness goes. Of course, we can never afford to ignore the latter, but, as we have considered it so very fully, we may now make it, perhaps, more of a secondary question.

So far we have only discussed the question of figuring on fabrics in a general way, without entering into the question of arrangement of figured patterns. The designs with which we have dealt, except in double cloths, have been figures of a simple description, commonly designated twills, the one chief characteristic being that they are continuous and unbroken all over the fabric. The number of threads occupied by one complete pattern is very small, and although, as we have shown, there may be a great number of patterns produced, either of twills or having twills for their base, yet there is little room left for the play of imagination, at any rate as compared with what may be exercised when dealing with designs of a floral character or patterns occupying a larger area. Again, the patterns with which we have dealt in detail—except the references made in the last chapter to figuring with double cloths—being such as occupy only a small number of threads, are capable of being woven in the loom with healds; but as the area of patterns so woven is necessarily limited, we must resort to the Jacquard machine to enable us to produce larger and more complicated patterns, or, in other words, to give us command over a greater number of threads, so that we may vary their order of working in a greater degree, and not have the repetition of the pattern occurring so frequently.

In all the patterns which we have discussed up to now, where we have formed a pattern by interweaving the warp and weft threads in varied order, it has been formed by both sets of threads in a similar degree. We have had no fixed or definite ground fabric with

a figure upon it. The figure has covered the whole; in fact, we may be said to have been designing fabrics. There has been only ornamentation on a small scale in the structure. We must now determine the structure of the fabric first, or what is technically termed the ground pattern, and then work our design upon it. For forming the figure upon the surface of the cloth, we may use either the material which composes the body of the fabric or we may introduce extra material. Suppose we are weaving an ordinary plain cloth, and we wish to ornament it by the introduction of a figure, we may either introduce additional warp or weft to make the figure, without in any way interfering with the plain fabric, or we may let the ground warp and weft, as that which forms the fabric is termed, cease to interweave with each other, and simply lie loosely one above the other at intervals regular or irregular according to the arrangement of the figure we desire to produce. Sometimes we may have the weft thrown to the surface, sometimes the warp, according to the material of which each is made; or we may bring up portions of each for the purpose of producing some special effect, as, for instance, if warp and weft are of different colours. In many cases also we not only make figures with the material of which the ground or body of the fabric is composed, but we also introduce along with it some extra material either in the warp or weft, or both.

We must examine into this subject very closely, so that we may see clearly not only how the figure is made, but the arrangement of designs, and the probable effect upon the fabric of designs of different characters when the pattern is formed by the ground material.



Fig. 77.

70. Figures Formed by the Ground Material.—Let us take Fig. 77 as a plan of a small figure, formed by the ground weft upon a plain cloth, and Fig. 78 as a section of the same. The general body of the cloth is per-

fectly plain, the warp and weft passing over and under each other alternately, but the figure is formed simply by their ceasing to interweave, each set of threads being quite free from the other. When figures are so made the quality of the cloth must be in some degree affected; but this will vary according to the amount of figuring introduced, the size of the separate figures, and their distances apart. We say that plain cloth is the most firm in texture of all ordinary fabrics, but if we intermix with the plain a quantity of figuring where the warp and weft are both quite loose, we make the fabric loose in texture exactly in the degree in which we figure it. Generally speaking, the amount of figure introduced is not so much as to affect the fabric detri-



Fig. 78.

mentally, but this, of course, must be carefully watched by the designer of the pattern; and if his cloth would be deteriorated by the introduction of a certain amount of figure, then he must alter it by the use either of a greater number of threads per inch, or of a thicker yarn. The consideration of the structure of the fabric, as affected in this way, is not the only or even the most important one in designing figured goods, but the arrangement and distribution of the figure also require a proper amount of attention. If the design be floral it will be necessary to distribute the weight of figuring equally, not alone for the purpose of pleasing the eye, but so that the fabric shall not be more loose at one part than another. It must always be borne in mind by the designer of fabrics of this type that large figures or figures set closely together will give looseness and extreme softness to the cloth. And by having a large quantity of loose weft or warp thrown to the surface the wearing qualities of the fabric are very much affected; in

fact, where the figure is formed there is no cloth—cloth has ceased to be formed, it is simply loose warp and weft, and it does not require an expert to know that this must not be carried too far. In a great portion of the fabrics figured upon this principle the designs are not strictly floral. Perhaps floral objects may form the basis of the design, but they are set at regular intervals over the surface, not arranged as a continuous pattern, not a design, perhaps, in the general acceptation of the word, but simply an object or number of objects scattered at regular intervals and in definite order over the surface.

Take Fig. 79 as an example. We have here the same object as we used in Fig. 77, but a number of them are distributed. So as to arrive at a definite understanding

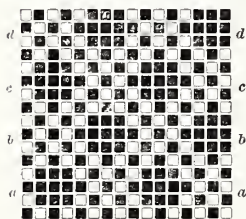


Fig. 79.

of the order of arrangement we must examine each spot or object and its relation to each weft pick and warp end of the pattern. It will be noticed that the spots *aa* each commence on the same pick, and so do *bb* and *cc*, &c., and further, that *a* and *c* are upon the same warp ends, and so are *b* and *d*, so that *a* is a repetition of *a* in the direction of the weft,

and *c* is a repetition of *a* in the direction of the warp; and in like manner *b* and *d* are repetitions of *b*. Consequently *a* and *b* constitute the complete pattern, the rest being simply repetitions of these two. This mode of arranging the spots is usually spoken of as being "two spots set alternately," which simply means that there are only two spots in the complete pattern, which are arranged so that they occur alternately in the order of weaving. This is the simplest and easiest mode of arranging the distribution of spot figures over the surface of the fabric, and may be applied to figures of any size or form, but it possesses what is generally considered a disadvantage in

woven fabrics, as far as appearances go, but which is much greater so far as the structure of the cloth is concerned. In the pattern before us, if we glance along the centre of the figure we see the weft passing clear over five warp threads, and interweaving only with three. Exactly the same occurs with the warp threads through the centre. Again, if we look along the line where one figure is just ending and the next beginning, we shall see that the weft passes under and over every alternate warp thread. The same also occurs with the warp thread interweaving with the weft at the corresponding position. Such a variation in the order of weaving of the various threads of which the fabric is composed must produce irregularities in its texture, which are objectionable, for they not only detract very much from its appearance but also from its usefulness, because of the different degrees of tension thrown upon the threads. In a figure so small as this it might not be serious, but in a large one it certainly would, and the small pattern is used here only for the purpose of illustration.

Then, if the arrangement of spots alternately in this manner is objectionable, as it evidently must be in some cases at least, we must adopt some other mode which will obviate the difficulty. Now, it is very clear that whatever system of arrangement we use, there must be regularity: the spots must be regular distances apart, and equally distributed. Fig. 80 is one of the most perfect arrangements of its kind. Here we have the same spots; they are equal distances apart, equally distributed, and the order of interweaving of each respective end and pick is also equal. The appearance of the fabric, so far as size and distance apart of the spots are concerned, would be exactly the same as that of Fig. 79, but the cloth will be more perfectly

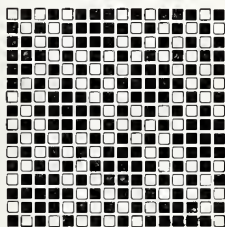


Fig. 80.

constructed, more pleasing to the eye—inasmuch as the figures do not run in the same straight lines—and more serviceable, because of the equality in the tension of the threads by reason of their interweaving regularly and equally throughout. This arrangement is extremely simple, being upon the basis of what is commonly known as an eight-end satin. In some cases other orders of satin may be adopted, doubtless for a good and sufficient reason. We must, of course, calculate the area we propose to give to the figure, and find the number of ends and picks it will require to occupy, and if that number happens to be one which is not a measure of the number of hooks contained in our Jacquard machine, which simply means the total number of threads at our disposal for figuring purposes, then we must alter it and adopt five, six, eight, or ten, as the case may require. Again, perhaps the form of the figure is such that an arrangement of eight spots in satin order would give them the appearance of irregularity; if so, we must adopt some other system which is better suited to it. For instance, an elongated figure may frequently be better arranged with five or ten spots than eight, because the order of distribution is not quite so regular to the eye; and this apparent irregularity may be neutralised by the placing of the elongated figures, and thus present a much more regular appearance. On the other hand, as a matter of course, if the spot is regular in shape, no method of arrangement can be better than an eight-end satin. Although the example we have taken for our illustration is a figure of a very stiff character, and one which perhaps exaggerates the difficulty, yet the rule is more or less applicable to figures of every description, whether they be stiff or free in their outline. No doubt the difficulty is greatest in figures which vary so much in the length of “float”—that is, in the number of ends over which the weft passes without interweaving. If they are pretty equal in this respect, then the only reason for abandoning the alter-

nate order of arrangement is to prevent the figures from running in straight lines across or the length of the piece.

So far we have confined ourselves to figures upon a plain cloth, and formed with the material of which the fabric is composed; but we are not necessarily confined to plain cloth; we may figure with equal facility upon twilled or satin cloth. In fact, we determine the fabric first, and then figure upon it; and the figure must be made subservient to the structure of the cloth, not the cloth to the figure. What we mean is, that we determine the weight, quality, and texture of our cloth, according to the purposes to which it is to be applied, and then proceed to ornament it.

In ornamenting twilled or satin fabrics, there is less risk of affecting the general character of the cloth than in plain cloth, because the looseness of the figure more nearly accords with the nature of it, the looseness of the interweaving of the ground of the fabric approximating more closely to the figure; and as there is necessarily more material employed, a slightly increased looseness is not so detrimental. Further, in cloths which have not a plain ground we employ figures with more freedom of outline. In plain cloths we are bound to consider the order of interweaving, and as this happens at every alternate end, our outline must necessarily be more or less stiff; whereas in a satin, for instance, the interweaving would be only at every fifth end, and we can, therefore, change from weft to warp, or *vice versa*, with more freedom, and consequently relieve the outline from stiffness. This is also assisted by the increased quantity of material employed.

One feature of the arrangement of spot figures must not be overlooked, whether we arrange them alternately, or in satin, or any given order. If the form of the figure is such that more threads are used in one direction than the other, whether in the warp or weft, by one spot, whatever number of spots are employed, the whole must occupy a space proportionate

to that occupied by one. Suppose, for instance, that one spot occupies thirty ends, and only sixteen picks, and we are employing five, eight, or ten spots, the number of ends and picks which the whole number of figures occupies must be proportionate to those occupied by one spot. It would be absurd to put eight, say, of such spots upon a square space; at some points, if they were not actually touching each other, they would come very near, while at others they would be very wide apart.

In many instances, when we figure with the ground weft or warp, or even with both, upon a plain cloth, the figure is not allowed to be quite loose, but is twilled, or the warp and weft are bound together in satin order; and even upon other than plain fabrics this may be done. The first object in doing this is to give firmness to the cloth, and sometimes also effect to the pattern. If the spots be large ones, the introduction of twilling will give more effect, more light and shade, as it were, to the pattern, and at the same time the cloth will be more useful for wearing purposes, and there will be less loose material on the surface.

Spot figures of the type of which we have been speaking are amongst the simplest and easiest patterns to produce. They require simple, methodical treatment only. We take any small object, either from nature or fancy, and distribute it in regular order and with mathematical precision over the surface, so that the designer's skill—from an art point of view—is called forth chiefly in the selection of his object. He will have no difficulty in finding plenty to select from. If he wishes to have large figures he has a great variety of flowers, leaves, &c., from which to select, which readily admit of variation, and which he may conventionalise to an unlimited extent. If only small objects are required, the number to choose from is even greater. The petals of flowers, grains of corn, portions of leaves, and other objects in nature, afford him unlimited scope.

In many cases small objects which are stiff in outline

are arranged in such order as to form a continuous pattern, like that shown in Fig. 81, which may be compared to a series of intersecting diagonals, made by objects each of the same size and shape. In patterns of this type effect is frequently given by variety of twilling, and at the same time the balance of pattern or looseness of weaving is regulated by it. In this design, for instance, the thick bars where the weft is laid loosely on the top of the fabric are coincident with the plain cloth, whilst at the point where there is little or no plain the figure is twilled, thus giving a balance or equality of texture.



Fig. 81.

In the arrangement of these patterns too much attention cannot be paid to such little matters, for the same reason that in the small set spots we distribute them in satin or some other order which will equalise the interweaving. If our pattern will not admit of such orders of distribution, we must take other means of equalising the texture.

71. Floral Designs formed by the Ground Weft.—In making floral designs, all the same conditions must be observed as in the patterns of which we have just been speaking. We must take care that our pattern does not run in too straight lines either with the weft or warp. It may be permitted to run diagonally, because that would not affect the relative tension of the threads. Any inequalities may be neutralised by varying the twilling, and by the same means variety given

to the pattern, and to some extent the absence of variety of colour supplied.

In some cases, where the floral design is of a scroll character trailing over the surface, after the fashion of climbing plants, with leading or prominent objects occurring at intervals, it is well to arrange these first, so as to ensure their equal distribution. They may be placed in satin, or some other more or less regular order, and the general body filled up afterwards, and in such a manner as to relieve the stiff monotony of the regular order of arrangement. If this is done judiciously, not only will it assist beginners in their first arrangement of original designs, but it keeps before their eyes constantly the necessity of this regular order of distribution; and a thorough conviction of the necessity of this, so as to keep the fabric regular, is one of the surest guarantees of success to the designer of textile fabrics.

72. Figured Stripes.—In many cases figures are made to run in regular stripes the whole length of the cloth; that is, a stripe is produced upon the fabric by figuring alone. It may be that the stripe is a floral pattern, and the ground is either plain or twilled, or has small spot figures distributed over it. In such patterns care must be taken as to the relative tension of the warp threads of the stripe and ground fabric, or, if there be a great difference, the warps for each respectively must come from different warp beams, because it would require so much more length of warp to make a given length of cloth in one ease than the other; and if they both come off the same beam, the same length of each being given off, one would of necessity be much tighter and straighter than the other. Of course the necessity for two beams would only arise when the difference in the orders of working made a very perceptible difference in the tension of the warp. Sometimes the figure of the stripe may be of the same character as the ground, but differing from it either in some of the forms employed, or in the arrangement or distribution of the objects, and

the difference in the orders of working might be so slight that there would be no real difference in the tension, and consequently no need for the employment of two warp beams.

73. Stripes which differ in Texture and Quality from the Ground.—We have already referred to making stripes finer than the ground, or what is called “crammed stripes,” but we spoke of them merely as plain stripes, or simply twilled. The same class of stripe is also largely used for figured goods. The ground of the fabric may be either plain or twilled, or may have spot figures over it—the last two are the most common—and the stripe may be twilled or satin, and the figure running upon it.

This is by far the most effective method of making stripes, because not only does the figure give character to it, but its very closeness and compactness distinctly mark it, and separate it from the ground. Again, stripes of this description are frequently a different material from the ground, as well as a different colour or shade of the same colour. When we say that these stripes are usually finer than the ground, we say so in a very broad sense, or perhaps it will be better to qualify it, and say that it is either much finer or there is a greater quantity of material in a given space. For instance, if the stripe be twilled, we may either have more threads per inch than in the ground, or an equal number of a thicker thread. The latter possesses the advantage of being cheaper, but the former that of superior appearance. If the stripe be a satin, we cannot so readily resort to the thicker material only, as the nature of the pattern requires a greater number of threads to make it “cover” properly. In either case there must be an increased quantity of material, whether there be actually increased weight or not. If we simply use thicker threads there will be increased weight, but if we use more threads of a finer count the increase of weight accompanying the number of threads is neutralised by their fineness in a greater or less degree.

In making figured stripes, the same rule must be observed as in the combination of any two patterns in any form—namely, that either the number of picks occupied by the ground pattern, or whichever is smaller, must be a measure of that occupied by the stripe or larger pattern, or they must be continued to a point where the two meet at the same time. In the majority of instances, the stripe will occupy the greater number of picks, because that is usually the fancy portion of the fabric, the ornamental part put on as a decoration to it. But this is not the universal rule; sometimes the ground may be figured, and the stripe a plain twill or satin introduced to give relief to the ground. This may be determined variously by the caprices of fashion, or the uses to which the article is to be applied. An example of each kind is given in the coloured plate I.

When the figuring occurs on the stripe, the best effect is generally obtained by having the ground darker than the stripe and solid in colour; that is, the weft and the warp of the ground both alike in colour, whether they are in the material or not, and the warp of the stripe either a lighter colour, or a somewhat lighter shade or tint of the same colour. By this means the figure on the stripe will be darker than the stripe itself, and will therefore give more effect to it. Where it is a plain stripe upon a figured ground the same rule will apply to some extent, but more liberty may be taken. A light figure upon a dark stripe will give a rather “seedy” appearance, it will be wanting in force or character, but a dark solid stripe upon a light figured ground will not be deficient in the same degree. Or even if the plain stripe be of the same colour as the ground, it will be more pleasing than a figured stripe upon a plain ground of the same colour. In the first case the stripe will break, and give relief to the figure, but the plain ground cannot give relief to the figured stripe to the same extent. Of course this will somewhat depend upon the relative quantities of stripe and figure; if they are equal, or nearly equal, the



PLATE I.

condition will not be exactly the same as if the ground be three or four times as broad as the stripe. The designer must be guided by this in his use or non-use of different depths of colour, as well as by other circumstances accompanying it.

74. Figures running over both Stripe and Ground.

—Although we have been speaking of figuring the ground and stripe separately, we are not, necessarily, bound to confine ourselves strictly to that. Very excellent effects are produced by letting the figure run over both stripe and ground; in fact, arranging the pattern as though the stripe had no existence. This may be done whether the stripe be finer than the ground or not, though in most cases it has most effect when stripe and ground are equal in all respects except colour; as, for instance, if the fabric is a fine satin throughout. Again, very pleasing effects may be produced by letting the figure run over the ground in sprays, and have the termination of its branches in the stripe; and this may be done either when ground and stripe are equal or otherwise. Probably in such cases the best effect is produced when the stripe is finer than the ground, as it will give a more striking contrast to the terminals of the sprays. If the object of running the figure over ground and stripe alike is to break up the stripe a little, and make it lose some of the harsh straight outline which usually distinguishes stripes, it will be better to let the stripe and the figure occupy different numbers of ends, or, in other words, occupy different spaces. Suppose, for instance, that the stripe is repeated every three inches and the figure every four inches, then the stripe will not be broken by the corresponding part of the figure until it has been repeated four times and the figure three times, so that it is relieved considerably of the monotonous repetition which would present itself if the stripe were broken all across the piece at the same point. This, of course, may or may not be an advantage, but in most cases it is a most decided one, because the harsh outline

and the individuality of the stripe are more completely and effectively broken up. We give examples in Plate II. of two figured stripes, one of which has the figure running indiscriminately over the surface, and the other having the terminals of the sprays in the stripe. Sometimes small stripes are made running in thin, straight, lines, and broken either with figures similar to those shown in Plate II., or with small spot figures arranged so that they fall across the stripes and break the lines. Such spots are best arranged in satin order, so that they don't break in straight lines across the piece. In fact, the same reasons prevail as for the spiral scroll and other similar figures previously mentioned to prevent the too frequent repetition of the break in the stripe from being in the same straight line.

75. Figured Diagonals.—In addition to figured stripes there is another class of figures nearly akin to them—namely, figured diagonals, or stripes arranged diagonally across the fabric. These, of necessity, differ from stripes running the length of the piece, not only in appearance but in the order of arrangement; and while in figured stripes we may have the stripe different in both colour and fineness from the ground, we cannot have it so in diagonal patterns, from the fact that the diagonal stripe must be made of the same warp or weft as the ground. We might introduce extra material for producing the diagonal stripe, but as we shall show when dealing with the question of figuring with extra material, we should add to the weight of the cloth considerably; and at present we wish to deal with figures formed by the material composing the ground cloth only. It may be said that in dealing with stripes of a different colour from the ground, and, perhaps, in different material also, we are ornamenting with extra material. That is quite true, but it is not figuring with extra material in the general acceptation of the term. When we are making that stripe, it forms the *whole* fabric at that particular place; there is no ground cloth under it;



PLATE II.



while what we usually mean by using extra material is that the ground cloth runs throughout, and the extra material figures *upon* it, and does not enter into the body of the fabric, *except to form figure*.

Then in figured diagonal patterns we are dependent upon form or variety of lines to produce variety of patterns; unless we do introduce extra material we cannot resort to variety of colour to assist us. But even when confined to single colours, we may produce great variety of patterns. In the first place, our pattern may consist more or less of scroll or sprays, running continuously diagonally, yet the variety of forms may break the rigid straightness of the line, or we may use straight lines with floral or other spots introduced at intervals between the lines. Again, we may use the straight lines combined with the scroll, and the scroll may be either confined strictly between the lines, or, like the stripes, it may break through it at intervals, regular or irregular. In fact, all that has been said of producing figured stripes so far as the design itself is concerned, apart from the use of colour and varying degrees of fineness, applies equally to figured diagonals. One remark which was made in a previous chapter in reference to small diagonals with spots running between them, also applies here—namely, that the number of ends occupied by the figure *counted in a diagonal direction*, must be a measure of the number occupied by the whole diagonal, or the pattern must be repeated to a number of which each is a measure. It is even more important that this rule should be borne in mind in commencing to make a large figured diagonal than in a small one, because any discrepancy between the number occupied by the diagonal and the figure respectively would lead to the necessity of carrying the design out to an immense length, and the increased number of ends employed makes it so much easier to arrange before the design is commenced that the two numbers shall coincide than is the case in smaller patterns. We might say that a little carelessness or

ignorance in the application of this rule will lead to a great waste both of labour and material which might quite easily be saved.

76. Combination of Figured Stripes and Diagonals.—Not only may we make figured stripes and diagonals, but we may also combine them, running figured diagonals between the stripes. In the arrangement of such patterns the rule of determining the extent of the design will apply as to stripes, but it need not apply as to diagonals. The diagonal must be repeated so as to show no break throughout the length of the piece, but it is not necessary that it should be a true diagonal across the piece. It is broken up, as it were, into long narrow strips contained between two parallel lines; then it must be perfect as between these parallels, but it need not be arranged so that it would be a perfect diagonal if these parallel lines or stripes were removed. Perhaps if the stripe were a very narrow one it would have a much better appearance if it were so arranged, but if the stripe be sufficiently broad to prevent the eye detecting any break in the continuity of the diagonal, it would not matter whether a break occurred or not. True, the effect would, in most instances, be more pleasing could any break—whether actually visible or not—be prevented; but what we mean by calling attention to this is, that if any extension of the design were necessary to prevent this break, provided no actual fault would be visible, it would be more economical to allow the break to take place, because it would, in many cases, require—in order to avoid it—an extension of the Jacquard power, and probably also a greater number of picks in the pattern, which would mean the use of a greater number of Jacquard cards, and consequently entail more labour and expense in producing the design in the fabric; and whenever labour and expense can be saved it is certainly advisable to do so.

77. Figured Checks.—In addition to stripes and diagonals formed by figures, we may also make checks or

stripes crossing each other at right angles. These may be classed generally under three heads:—First, when a figured check encloses a plain, square space; second, when a plain check encloses a square figured space (in both cases the check lines being equal in texture and quality to the space enclosed); and third, when the check lines are different in quality and texture to the space enclosed.

In arranging designs for the first of these care must be taken that the figures running across the piece and those running the length of the piece join perfectly to each other. The two portions of the pattern must not have the appearance of having been made at different times, or by different hands, and put together by chance. They must combine to form one complete whole. They must be part and parcel of the same idea, otherwise there will be an incongruity about the pattern which will be most offensive to the eye. Patterns of this kind in the hands of a beginner are, perhaps, the most difficult to manage; the point of junction is often to him a source of much trouble. It may not, perhaps, be such a very difficult matter when making a design upon plain paper, but when he is applying it to the fabric, where he has to follow the warp and weft thread by thread, he often finds considerable difficulty. This difficulty is by far the greatest if the pattern has any stiff, rigid lines. These must fall in and join to each other perfectly. If the slightest break occur, it will be immediately visible. If the pattern run in flowing, graceful lines, the difficulty will be lessened, because a slight deviation will not be in any way detrimental, though it must never be attempted with stiff lines. The length of the lines must be measured with the most perfect accuracy, and the chief points carefully marked out upon the design-paper, so that nothing which will affect or be likely to affect their joining properly will be left to chance. We have thought it well to give this warning most explicitly, knowing the liability of the beginner to fall into error.

which would result in spoiling his whole pattern, and compel him to begin the task again.

In the second class, where a figure is surrounded by a plain check, there is no necessity for this caution. Each square of figure is complete in itself, and, even more than in the striped diagonal, no regard need be paid to its continuity. It may be treated as we might treat a tile, or any square article with a figure in its centre and a border surrounding it. This border will prevent effectively the adjoining square from interfering with it. In fact, the different squares need not be all alike; different patterns may be alternated, and as much variety as the extent of figuring surface will permit may be introduced. There is no difficulty in arranging designs of this kind for the fabric.

In the third class, where the check surrounding the figure is of a different quality from the ground, what has been said of the second class applies exactly so far as regards the figure, but in respect to the check itself some knowledge of the structure of fabrics is required. We may say that it is a combination of two stripes placed at right angles to each other, both of which are finer than the ground fabric which they surround or upon which they are placed. Now, whatever may be the texture and degree of fineness of the longitudinal stripe, that of the transverse stripe should be exactly similar. If these two stripes or sets of stripes be much heavier or more compact in their structure than the ground cloth, they will exert a power over it, and cause it to "cockle" or curl. On the other hand, if the ground be firmer in texture than the stripe, it will exert a similar power over the stripe.

From the very fact that the stripes are finer, containing a greater number of threads per inch than the ground, they must be more loosely interwoven, so as to allow of this increased quantity of material being put in.

This being so, if the relative quantities or thickness of the materials of the ground and checking be

not properly proportioned to the order of interweaving of each respectively, trouble must of necessity ensue. Therefore, too much care and attention cannot be paid to the subject before actually attempting to make the pattern.

78. Diaper.—In all the patterns with which we have been dealing we have assumed that the figure is formed by the warp and weft ceasing to interweave with each other, or if not entirely ceasing, interweaving only very slightly—just sufficient to hold them together and prevent them from appearing as so much loose material, or to give some special effect to the design. We may now turn our attention to a class of figuring in which throughout, both in figure and ground, they are equally firm in texture. Such patterns are variously known as “diaper” and “damask.” The former is not so much used as it once was, the latter, which permits of much greater variety of form in the figures, having, since the great development of the Jacquard machine, almost entirely superseded it. However, both are alike in the principle of structure of the fabric, and it is probable that diaper preceded and was the original of damask, which, with improved machinery, has developed into a more perfect and pleasing class of designs.

In Fig. 82 we have a plan of a diaper pattern of the simplest kind, which will convey most readily an idea of the principle upon which the fabric is constructed. On the first eight ends and picks it will be seen that the weft comes to the surface, forming

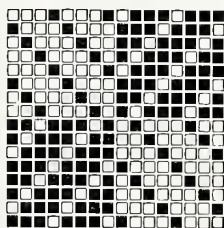


Fig. 82.

a four-end twill, and for the next eight ends exactly the reverse taking place. There is still a four-end twill formed, but running in the opposite direction, and with the *warp* brought to the surface. For the next eight picks the conditions are reversed, the ends which went

to the back at first now coming to the face, and those which were on the face going to the back, and the twills turning in the opposite direction at the same time. Throughout the whole system of diaper weaving this one principle is followed. The figures are formed by the warp and weft changing places from back to face and *vice versâ*. In whatever direction the twill runs when the weft is on the surface, it runs in a contrary direction when the warp is on the surface; consequently both sides of the fabric are alike in pattern, and, what is quite as important, the fabric is equally firm in texture throughout. There is no loose material on face or back.

The pattern we have given in Fig. 82 would form a simple chequer pattern, but generally they are of a more elaborate character than this. The intervals of changing may be varied to any extent, and not only simple chequer patterns produced, but others which may almost be called figured goods. In all true diapers the chief characteristic of the pattern is that it runs in squares; the whole design is simply the changing of the order of working, as shown in Fig. 82, in various-sized squares or parallelograms. Fig. 83 is a plan of one in which there

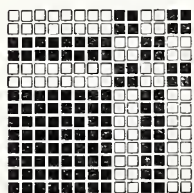


Fig. 83.

is greater variety than in Fig. 82.

It is not carried out to the full extent, nor shows the twilling, but is simply made upon paper to explain the pattern. In arranging designs for diapers the plan adopted in Fig. 83 is a very general one—at least, when woven as diapers formerly were, with healds. The warp is divided into divisions of four or more ends, ac-

cording to the pattern; each of these divisions is represented by one of the spaces on the paper, and all the divisions which correspond in their order of working have their warp threads drawn through the same set of healds, so there are as many divisions of healds as there are divisions of the pattern which are different from

each other in their order of working. So that, as will readily be seen, very large patterns may be produced with a very small number of healds; and if each of the spaces given on the paper represent a division of four ends, the whole pattern will be four times the size of that represented. Of course, what is said of ends applies also to picks.

There are many small patterns in both linen and cotton goods which are known as diapers but are not in reality such. They are simply small figures, many of them made on the principle we have before described—namely, a loose weft or warp figure upon a plain or other ground.

It may seem that if diapers are, as shown here, a mere combination of twills for the purpose of producing patterns, that the subject should have been treated under the head of figuring with twills in a previous chapter. Strictly speaking, that is so; because they are not only patterns which were always produced with healds in the days when they were most largely used, but the character of the pattern altogether would place it in the category of those with which we have already dealt. Our sole object in reserving it for this chapter has been to use it as an introduction to damask. In speaking of diaper patterns we have referred to them as being regular twills reversed to form patterns. This is a perfectly accurate description of the great majority of diapers, but sometimes instead of a regular twill a satin would be substituted, the pattern still being arranged in straight lines, squares, or parallelograms.

79. Damasks.—The structure of damask is precisely the same in principle as that of diaper. The figures are not arranged in straight lines or squares, but are generally more or less of a floral character.

It is supposed that the silk weavers of Asia invented diaper weaving. Damask, which was formerly made entirely of silk, though now both of worsted and linen, takes its name from the city of Damascus, whence it

is supposed to have come. So that it is probable that, as we have already said, the diaper is the original of the damask; and although we now apply the name exclusively to the class of patterns we have been describing, yet the two are practically the same thing so far as structure of the cloth is concerned, and the one is the outcome and development of the other so far as character of design goes.

In damask figuring we have, perhaps, more scope for producing large figures than in any other mode. Generally the ground is warp satin and the figures weft satin, or it may be the reverse. In either case the binding of the weft and warp together is the same in both ground and figure, so that the cloth is equally firm throughout. That being so, figures as large as we please may be introduced. It is not a question of having so much loose material on the face or the back, but merely the exchange of places of warp and weft, the two continuing to interweave in the same order whichever may be uppermost. One matter relating to the structure of the cloth requires notice here. We have said that to have a perfect structure of cloth the relative proportions of warp and weft must be regulated by the pattern of the fabric. In damask weaving what is termed the pattern of the fabric is that of the ground, or the general order of interweaving, which is usually a satin. To make a satin perfect with the warp predominating on the surface, we say that there should be a greater number of warp threads per inch than weft; and if the weft be on the surface, there should be a greater number of weft threads per inch than warp. Now, in damask we have the warp and weft on the surface alternately, and each weaving as a satin. Perhaps there may be nearly equal quantities of each, and at any rate both are on the surface at different parts of the cloth at the same time; then it is quite impossible to comply with the conditions required to produce a perfect satin. We cannot make either material

predominate just at the point where it comes to the surface, and nowhere else; if one predominate it will do so not only in the figure or ground, but in both. Then we are reduced to the necessity of making the fabric equal both ways, that is, warp and weft will be equal both in quantity and thickness. But that equality will not be the same as for a plain cloth. In plain cloth, we say, to make perfect structure, not only should warp and weft be equal in quantity and thickness, but the intervals between the threads should be equal, or nearly so, to the diameter of the threads, so that warp and weft threads may bend round each other equally. In satin cloth the threads do not interweave alternately, but at least once in every five. Then our threads must be closer together than for plain cloth; but as both sets of threads come to the surface neither must be set so closely as if only one were intended to come to the surface, but just so that both warp and weft will have to bend a little out of the straight line, without departing so much from it as in a satin of a perfect type.

The outcome of this must be, then, that in a damask we cannot have a perfect type of a satin. We certainly cannot, but we must come as near it as we can, consistently with the fact that *both* sides must be equally perfect, and not one side only. An examination of damask cloth, either in linen or worsted, will convince even the merest tyro of this, and more especially if he compare it with satins which are not figured after the style of damask. Instead of there being a fine unbroken surface, presenting only one set of threads to the eye, either in the ground or the figure, and all the points of interweaving of the warp with the weft being hid, he will see the weft come through to the warp surface, and the warp come through to the weft surface. The thicker the threads employed the more apparent will this be, and the thinner the threads the less will this be visible. The reason is not hard to find. Where the threads are thick the point of interweaving is

more difficult to cover, by reason of their bulk, even if the threads on each side spread out pretty well; but if the threads be thin, and those on each side of the point of interweaving spread out slightly, it will have a better chance of being covered; hence fine cloths present a more perfect appearance than coarser ones, although the diameters of the threads in both bear exactly the same ratio to the number in a given space. Although damask patterns are usually made upon fabrics with a satin ground, and the figure, as we have said, is produced by the warp and weft exchanging places on the surface, yet they are not necessarily confined to that only. As in other fancy cloths, variety of working may be introduced to give more effect to the figure. At points where some special effect is desired the satin may be exchanged for a twill, and the twill may be varied in its direction, or even in its order of weaving. Sometimes small spots of weft or warp are introduced to give additional variety and effect to the pattern, but in all cases care must be exercised not to make the fabric too loose at any point. The general practice is to make these goods all of one colour, as, for example, in linen table-cloths and similar articles, and again in worsted damasks for furniture purposes. So that the whole effect of the pattern is dependent upon the threads of which it is composed, and which are placed at right angles to each other, being brought to the surface alternately, according to the form of the figure, and thus, by the light falling upon them at different angles, relief is given. It will be easily understood that a little variety in the order of interweaving the threads in the pattern, instead of keeping strictly to the ground pattern as satin will give a pleasing effect of light and shade to the whole.

80. Combination of Damask and Repp.—Another type of fabric which is much used for furniture purposes is one which may be termed a combination of damask and repp, or a repp fabric with a damask figure upon it. The general body is constructed on the

principle mentioned in the first chapter, with a number of threads together as one, alternated with a single thread, and the ground of the cloth woven plain, so that all the thick or combined threads when passing over the pick form a distinct rib across the piece. For the purpose of figuring, those thick threads are allowed to "float" or pass over all the weft picks, so that they present a flat surface of loose warp upon the ribbed ground. This is all very well where the figures are small, and make stiff-looking objects, which run either across the piece or in diagonal lines; but if the figures are too large or too long in the direction of the warp there would be too much looseness, more especially for use in connection with articles of furniture, such as covering of chairs, &c. Then to prevent this looseness, and to enable the designer to employ large figures, the threads which combine to make a thick one are separated in the figuring, and woven into the ground weft in the order of a satin or twill. By this means not only the flat surface required is produced, but with the number of ends which they make when separated they cover the weft and the points of interweaving most effectively, and make a firm fabric; and in this, as in the damask proper, great variety may be obtained in the pattern by using a variety of twilling to give shaded effects. From the very boldness of the ribbed ground, the prominence of figures formed by the thick threads where they are not separated, and the flatness of the figure where they are separated, more effective and striking patterns may be made upon fabrics of this class than upon the ordinary damask. Quite as much extent of figuring can be produced, either floral or otherwise, and, of course, greater variety of effects. If proper regard be paid to the relative thickness and number of the threads according to the pattern, the cloth will be a most useful one also; but if this be neglected, in common with all repp goods, they will be liable to "fray," and be unserviceable for wear.

81. Figuring with Extra Material—Extra Warp.—

We have now examined pretty fully into the question of figuring with the material of which the fabric is composed. We must next enter into figuring with extra material, or the introduction of weft or warp, or both, for the purpose of forming pattern.

We shall now begin to find our knowledge of double cloths of value ; for the whole system of figuring with extra material may be said to be based upon double cloth, although two cloths are not actually formed. Even though we may not actually form two distinct cloths, yet we have one warp and weft making the fabric proper, and we have another weft, or warp, or both, forming figures upon it. In some instances, where we use both warp and weft extra, we may be said to actually form double cloth, at intervals, at any rate ; because if the extra materials interweave to make a figure, they will, as a matter of fact, at that point form a cloth of their own, separate and distinct from the ground cloth.

We will deal with this subject under the three distinct heads :—First, where extra warp only is used ; second, where extra weft only is used ; and third, where both extra weft and warp are used ; at the same time the combination of figures formed by extra material combined with those formed with ground material must be shown.

We will first take figures formed with extra warp, and deal with it in stripe form. Suppose we make a perfectly plain cloth for the ground, and we wish to make a stripe upon it either figured or otherwise ; we arrange the stripe ends in such a manner that they pass alternately to the face and back of the cloth, according to the pattern, but they take no part whatever in the formation of the cloth. When they come to the surface the ground cloth remains plain underneath them, and when they go to the back the ground cloth remains plain above them. Fig. 84 will represent a longitudinal section. In it

the ground cloth is shown as being quite plain throughout, and the thick thread, which represents the extra warp, is shown as passing from one side of the cloth to the other to form figure.

In the arrangement of fabrics



Fig. 84.

figured in this manner, the first condition, to ensure the figure being solid in appearance and effectually covering the ground, is that the extra threads should be set as closely together as ever they can be, and that they shall be of sufficient thickness to cover the interstices between them as nearly as possible. Those extra threads must, of necessity, be alternated with the threads of the ground warp; then, to ensure this solidity as far as may be, two conditions are requisite in the ground fabric: first, the ground threads must be set closely together, and second, these threads must be as thin as possible; and further, there should not be more than one ground thread between the extra ones. Suppose that the ground warp is set very openly, the extra threads have not only to fill the space between them, but it must spread out so as actually to cover them. If the diameter of those extra threads be less than the spaces, it cannot, of course, even cover these spaces; and if the diameter and space be equal, it of course can do no more than cover the space, so that there would be a space between each extra thread equal, at least, to the diameter of the ground thread, and that could not possibly show a solid compact figure on the surface. Again, if the space between the ground threads be small, but the threads themselves be thick, extra ones would undergo some compression at the the point where they are passing from face to back or from back to face, but they will still be unable to spread out enough to cover the thick ground threads; then there is only one alternative: if the

figure must show a solid surface, the diameter of the extra threads must be equal to *both the diameter of the ground threads and the spaces between them*. It will then, at the point of changing from one side of the cloth to the other, undergo a compression equal to the diameter of the ground thread, or rather the two threads together—ground and extra—will undergo this compression; and as the extra one issues from the cloth it will spread out to its full diameter, and so cover the ground effectively. If the “floats” on the surface be very long there will be all the better opportunity of covering, but if they be short these opportunities will be decreased. Now with regard to the question of compression. If the ground threads be “soft spun”—that is, not having much twist in them, the fibres lying loosely together—they will be all the more subject to compression, and the extra ones will keep near their natural state. On the other hand, as is most commonly the case, if the extra threads be soft they will undergo the compression. Probably the latter alternative is the better, more especially if we look at it from a practical point of view. The ground threads have to bear all the strain of weaving; they form the wearing cloth; they really constitute the fabric. The extra thread simply ornaments; therefore, for the convenience of the weaver, and to obtain the strongest cloth, the ground threads should be tolerably firm in their structure, and we may have the figuring threads soft and loose, so as to cover the ground in the most effective manner. We have been speaking now on the assumption that the ground of the cloth has to be absolutely covered by the extra material. We have done so to illustrate more clearly the true basis upon which we must work. It is well known that a succession of sounds, if sufficiently rapid, conveys to the ear the impression of a continuous sound; or, in like manner, a succession of sparks will convey the impression of a continuous line of light; then, if the colours of

our extra warp be brighter than the ground, as they usually are, although they do not entirely cover the ground, the spaces between them may be so small that they will convey to the eye the impression of solidity, or continuity of colour.

If we wish the stripe to appear solid, like some of those of which we have already spoken where they are "crammed," or have double the number of ends in a given space of stripe to what there are in the ground, we cannot obtain it so perfectly by treating it as extra warp, and allowing the extra warp to form figure upon plain ground, as if we employ all, both ground and extra, of the same colour to form the stripe. Nor will it have the same fineness of appearance. This will be very easily understood; by bringing extra warp to the surface to figure upon the ground, only half the quantity is presented to the eye that there would be if both ground and extra combined to form the stripe; and whether the stripe be twilled or satin, it must appear finer in the latter case.

On the other hand, the ground cloth being quite plain under the stripe will give a firmer and stronger fabric, and there will be less tendency to "cockle," because of the texture being equal throughout. Again, from an economical point of view it may be advantageous. If the ground of the cloth be of cotton warp, and the stripe silk, it will be much cheaper to make it as an extra warp stripe, because only half the number of threads would be employed. Perhaps those would have to be somewhat thicker than if the whole were silk, but still there would be an economy, though we must again say not so good an appearance.

It is not often, however, that this system of working is resorted to for the making of solid coloured stripes; more generally it is employed for figured ones, and then it certainly does possess advantages. The figure may be approximately solid in appearance and well defined, and the stripe may be broken up as much or as little as may be desired by the figuring.

Perhaps it will be necessary to show the arrangement of the design upon paper for figured stripes of this description. Fig. 85 is a design for a small figure. It will be seen that every alternate end weaves quite plain, and the figuring ends form figure only, and consequently may be brought to the surface as much or as little as we please. The figure may be large or small, or the stripe may be broken up so that there is little semblance of a stripe left, or it may remain nearly solid.

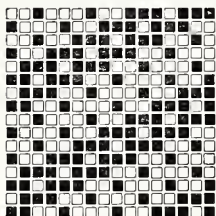


Fig. 85.

Very frequently, although the warp is introduced in stripe form, no stripe is formed, but merely spots; the warp coming to the surface to form the figure, then passing to the back and remaining there until required to form another spot. If the spots are some distance apart, the loose material at the back must be dealt with. It must not be left loose for any length; it must either be bound at intervals into the cloth, or cut away. Sometimes difficulties arise with this loose material. If the cloth be a thin one, and more especially if it be woven quite plain in the ground, the loose material which is not figuring cannot be bound into it without showing through to the surface, and it would be most objectionable to have it showing through in dots at all the points of binding. Thus there is no alternative but to cut it away. Then, again, another difficulty arises. If after forming the figure on the surface it simply pass to the back, as shown in Fig. 84, and we cut away that which is at the back, there will be nothing to keep the figure on the cloth but the slight pressure of the ground threads upon the figuring threads at the point where they pass through the cloth. This would certainly not be sufficient, at any rate, if the cloth is to be applied to any useful purpose. The least rubbing on the figure would bring it away from the cloth as so much

loose yarn. Then we must bind it into the cloth round the edges of the figure. The best method of doing this is to let the extra ends weave plain into the ground cloth all round the figure for a sufficient number of picks to make it firm, then the loose yarn may be cut from the back, but it must not be cut quite close to the cloth. Fig. 86 is a plan of a small spot showing the binding around the

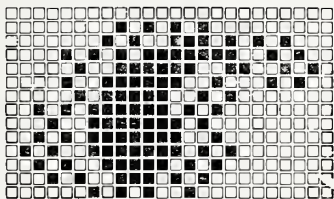


Fig. 86.

spot. If this binding can be introduced as part of the figure it will be all the better, and if some more can be introduced into the body of the figure better still. This may be done, not only as a species of shading to the figure, but also to give variety of effect to the colour. This subject of binding also brings another matter before us. We very frequently have to give variety and character to our figures by what might perhaps be called light and shade ; that is, we wish the figure to vary in the degree of prominence given to its various parts. At some points the colour should appear in its full intensity, at others in a somewhat subdued form, and again at others be modified to the extent of being almost invisible. To obtain these effects we must bind the figuring material into the body of the cloth in a sufficient degree, and in such order as will reduce the colour to what we want. This binding we may vary as we please. We may twill in either a bold or a very firm twill, or we bind in plain or satin ; our twill may throw a preponderance of the material to the face, or it may throw it to the back ; in fact, we may bring as much or as little as we please to the surface, and so produce any effect we desire.

If the fabric upon which we are figuring with extra

warp be a heavy one, we can deal much more readily with the binding. Should the ground be twill or satin instead of plain, we can bind into it at will, without its showing through to the surface, upon the same principle as binding double cloths. In fact, where the extra warp comes, we treat it as a double warp cloth, except where it is forming figure. In such cases it is not often necessary to cut away loose material at the back. Having facilities for binding, it is better to do so, not only because of the saving of labour, but also because the figure will be less liable to pull out in wearing. Where cutting is resorted to we can never be quite sure that the binding round the edge of the figure is sufficient, more especially if cut too close; therefore it is not desirable to resort to it, except under circumstances which admit of no alternative.

In addition to spots or stripes formed with extra warp, we may figure all over the fabric with it, and by this means produce not only very pretty, but very elaborate designs; for we may use more colours than one, and even with the use of one colour we have excellent scope for making pretty patterns. We have two illustrations in Plate 3 of figures formed with extra warp, one with the use of one colour only, and one with two colours. With regard to the arrangement of these two colours, they must of necessity be arranged in stripes in the warp, that is, a given number of ends of one colour, and a given number of the other, and so on. The first object, however, must be to arrange the design so that these stripes are not too apparent on the surface; the figure must be broken up in such a manner that the existence of the stripe is not too plainly visible, at any rate to the untrained eye.

This breaking up of the figure may be very materially assisted by the use of figuring with the ground material along with the extra warp, and if judiciously done, very pleasing effects will be the result. Again, to assist the breaking up of the stripes, we may vary them



PLATE III.

as much as ever we please in size, and at the same time we shall be varying the sizes of the different figures formed by each colour respectively at various points.

In arranging designs for figures formed with extra warp upon the design paper, proper regard must be paid to the relative quantities of warp and weft. Suppose all over the piece the extra ends are alternate with the ground ends, and that the quantities of ground weft and warp are equal, then the total quantity of warp will be just double that of the weft. In that case if the Jacquard machine with which we are to weave the cloth has eight rows of hooks, our paper must have eight divisions in one direction and only four in the other—what is known as eight by four paper. If we were to use paper equal both ways, the figure would of course be distorted, the width on the paper being double that of the length, if it were to be correct in the cloth; and if correctly drawn on paper, it would be drawn to double the length on the cloth in weaving.

82. Extra Weft Figures.—We now come to the question of figuring with extra weft. This mode of figuring possesses decided advantages over the system with which we have just been dealing, and has but one disadvantage compared with it. When we figure with warp alone we weave as if we were weaving a plain, twill, or satin cloth only; the weft which forms the ground serves also to bind the figure. Consequently we can weave at a more rapid rate, having to pass the shuttle a sufficient number of times to make the ground cloth only, whereas in weaving with extra weft we have to form the ground cloth and pass the shuttle to form the figure also. On the other hand, in warp figuring we have the warp very crowded. This adds to the difficulty of weaving if carried too far, so that in most cases we are confined to the use of one colour only, or if we use more, they must be arranged in stripe form, as shown in Plate 3. Now, in figuring with extra weft we may use as many colours as we please; it simply means the

use of so many more shuttles, and so much additional weaving; that is, the shuttle has to be passed through the warp so many more times, though this is necessarily accompanied by slow production. Again, by the use of the "swivel" we may dispense with the loose material on the back, and use only just what is required to form the figure; and there is also an advantage in putting the pattern upon design paper, no distortion being necessary, as we shall show.

All that has been said respecting the relative thicknesses of the figuring and ground threads applies to weft figures equally with warp figures.

It is not often that continuous stripes are formed across the piece with extra weft, though it may perhaps occur sometimes. If it does, however, it will generally be in conjunction with warp stripes, so as to form a check pattern, though it frequently happens that the weft is thrown all across the piece to form spot figures. In such cases, what has been said of binding and of cutting off loose material in warp stripes will exactly apply also to weft, so that we need not enter further into the consideration of that question. Let us, then, turn to the discussion of figures formed with the "swivel," and see what are the advantages to be gained.

What is known as the "swivel" is an apparatus attached to the loom, and carrying a series of small shuttles, each being intended to form a separate spot; and in the process of weaving, after the shuttle carrying the ground weft has been passed through the warp, the "shed" is opened, or the warp threads are separated for the weft which is to form the figure, and instead of one shuttle being passed all the way across the loom, carrying weft which has only to form figure at intervals of two, three, or four inches, a small shuttle is passed through the warp at *each* figure, so that each one is formed by its own weft and with its own shuttle. The advantage of this is obvious at first sight; there is no loose material to deal with on the back, and conse-



PLATE IV.

sequently no need either to bind into the fabric or cut away. Again, as each figure is formed with a shuttle of its own, they may be of different colours; whereas, if one shuttle must serve them all, they will, of necessity, all be of the same colour.

The swivel, from the fact of its being a series of shuttles, is specially adapted for the production of spot figures; and the shuttles all being of a given size, and set a certain distance apart, necessitate the figures being set in like manner; in fact, the position of the figures is determined by the position of the shuttles, and the distribution of the figures is determined by the number of positions in which the shuttles can be placed. We have in Plate 4 a small figure formed by a swivel. An examination of the figures will show that the space occupied by the figure is much less than that between them. Generally the space actually occupied by the figure must not be more than half the space between each; that is, if the width of the spot be one inch, there must be an interval of two inches between that spot and the next. This is entirely dependent on the construction of the "swivel" apparatus. There are several forms in use, some of which occupy much less room than others, and consequently allow the spots to be placed much nearer together. With swivel figuring we are not necessarily confined to simple spots, but may make figured stripes, after the character of those we have spoken of as being produced by warp. The shuttle being placed in one position, if we keep constantly weaving without changing it, a continuous stripe would be the result.

83. Combining Extra Weft Figures with Figures formed by Ground Weft.—Again, we may combine the extra figure with figuring produced by the ground weft. Suppose, for instance, we are wishing to weave a representation of a rose-bud. The leaves, stem, &c., may be formed by the ground weft, or we may use both weft and warp, and the bud itself may be formed by the extra

weft. By this system of combining figures some very pretty effects may be produced economically, but great care is required in the arrangement of the designs. We have already shown that the spots formed with the swivel must occupy certain positions, according to the arrangement for moving the shuttle from one position to another. If the figures so formed are to be combined with others, all must be arranged so that they fall properly into the places assigned to them.

Sometimes figures of this description are made with the extra material introduced as warp. In such cases the distortion of which we spoke with reference to warp figures occurs on the design paper; the extra ends coming in alternately with the ground ends only at intervals, the whole figure must occupy at those places double the space upon paper. The paper will be ruled alike throughout. As the conditions of the pattern alter, so also must the form alter upon the paper. In extra weft figure this need not be the case. The figure may be painted upon the paper in the various colours, and the rest will be arranged in cutting the cards for the Jacquard machine. When cutting the ground cards, simply treat the extra colouring as if it were ground, and when cutting the cards for the extra figuring deal with it *only*.

Swivel figures may assume a great variety of forms. They may be simple spots, or may introduce additional colour or colours into figures formed with the ground; or the spots may be surrounded by checks. They may form continuous stripes, or, by the judicious movement of the shuttles and corresponding arrangement of the figure, waved lines; or a series of figures broken in a greater or less degree may be obtained. In fact, there is scarcely a limit to the varieties; the only limit is the width of figuring which may be produced at once.

Although swivels may be used to give us these varieties of figures, with economy of material, yet we have often to step beyond their range. If our figuring occur too frequently, or occupy a greater area than



PLATE V.

the swivel can give, then we must resort to the ordinary shuttle, and throw the weft all across the piece.

If we throw the weft across the piece for the purpose of forming spot figures only, it will often be desirable to arrange the figures so that they shall not too strongly suggest a stripe. This may sometimes be the result of the arrangement of the figure formed by the ground material accompanying the extra figure; for instance, if the ground figure run in a diagonal direction, as in the designs in Plate 5, although the spots are really in straight lines across the piece, the general arrangement altogether neutralises it. In the first of these two figures the spots are so far apart that they might be easily woven with the swivel. It would only require to be so that it could be moved the requisite distance to suit each spot.

In the second design the spots are so arranged that the weft forming the large spots is at the same time forming also the small ones, yet there is nothing that will suggest to the eye a straight line of colour across the fabric. If the figures be large and rather close together it will not be easy to prevent the tendency to show stripes; but if they be small and well distributed it may be prevented without much trouble. If we use more than one colour in the same spot, as will often be necessary, it will be desirable as far as possible to arrange the colours so that one colour is ended before the other begins; or if that would make the division too harsh, let both colours run simultaneously for a short period. But in using two colours one of two things must be done—either the two colours must continue simultaneously throughout the fabric, or for a very short period only. As can be easily understood, if two extra colours come in together for a time, and then either one or both cease, or if one cease and the other shortly after, there will be great variation in the bulk of the cloth, and that variation will detract from its value as an useful article. We may introduce one colour at intervals and not materially affect the structure. If the cloth be a heavy one

we may, perhaps, introduce two, but if the cloth be a light one two will be dangerous. But if our colours be judiciously treated, and arranged in such a manner that one commences when the other has finished figuring, whether it be to take part in the formation of the same spot or another, then we may use them with freedom.

In Plate 6 we have two examples, one showing the use of two colours, or rather two shades of the same colour, which would necessitate the use of two shuttles, as though they were two colours. In one case both colours take part in the formation of the same figure, and in the other they form separate figures.

In the pattern when both colours go to form one figure, there is a tendency to show a stripe across the piece. Even if this occur only in a slight degree it will offend the eye; possibly it would be less offensive if the stripe were more decided: it can neither be called a figure free from stripe, nor can it be called a stripe. The latter is suggested without actually having an existence. This might be neutralised to some extent by the introduction of other small spots between, so as to break the line a little, or rather to show the colour more distributed over the surface of the cloth.

When we are figuring with extra weft we do not necessarily confine ourselves to its use for spot figures or stripes, but figure all over the surface of the cloth, and we figure not only with one colour but with many colours. In the common speech of the trade, when we figure with a number of colours all over the fabric, each colour is termed a "cover;" thus, it is no uncommon thing to hear the terms, "three cover," "four cover," &c. This means that three, four, or any number of shuttles indicated by the number of "covers" follow each other in regular succession in the order of weaving, or that every time a ground pick is inserted so many picks of extra weft, or that which takes no part in the formation of the cloth, only in figuring, follow it in regular succession. Sometimes



PLATE VI.

it may be spoken of as "three covers," or "ground pick and two covers," which would mean that there is a ground weft and two extra wefts. Again, in some instances we have a number of "covers" and "extras;" that is, a number of colours running throughout as figuring material, and an extra colour coming in occasionally to form some particular part of the figure.

Now, when we are making a cloth with a number of "covers," it does not necessarily follow that we are confined to that number of colours; though such is generally the case, one of the "covers" may be a "changing" one. Instead of always remaining the same it may consist of two or more, but always keeping the same relation to the others. When one colour has completed its portion of the figure another takes its place, and so on; so that if it is called a "three cover," there may be four, five, or even six colours, but there are never more than three wefts being inserted at once. Either one or two of the covers may be "changing" ones.

When we are making cloths of a number of colours, we cannot make them very light fabrics in weight, so that we have an opportunity of binding the loose material into the back. In some cases the extra materials instead of being bound into the face cloth, have a binding warp at the back with which they interweave, and form a separate cloth or "lining." This has two advantages: first, it enables us to deal readily with the extra material, and leaves none loose on the back, as well as forms a good support to the face cloth, giving additional strength; and second, it saves any risk of the binding showing through to the face. Again, sometimes there is a separate back put upon the cloth, so that all loose material which could not be conveniently bound to the face, and which might not be sufficient to form a separate cloth on the back, might be held between two cloths, and so give the cloth a "smart" appearance, as well as additional strength.

When we are figuring with extra wefts in this manner we have also the ground material which we may use for the same purpose, and thus give more variety to the pattern ; and in order to retain the full strength and compactness of cloth, when the ground weft comes to the face, one of the extra wefts takes its place, weaving into the warp as the ground weft ; thus forming, in addition to keeping the cloth strong and perfect, a more stable background for the figure, and throwing it more prominently to the surface. To such an extent is this carried sometimes, that it would be difficult to say which is the ground and which is the figuring weft. In figures of this description the same resource is open as in making spot figures by interweaving the extra or figuring material into the ground for the purpose of giving variety of shade to the pattern. If we are weaving, for instance, with black figuring weft upon a white ground, by allowing the black to enter into the structure of the ground fabric we may produce as much variety and as much delicacy of light and shade as in fine engravings.

Suppose we are weaving a small picture, a landscape, a portrait, or designs in which foliage or great variety of light and shade is required, and our ground cloth is a plain one. To obtain the deepest shadows, we should bring the black weft to the surface, and if it had to cover a large area, or such that if allowed to float for a considerable distance the weft would be too loose on the face, we should bind it in satin order just enough to attach it to the cloth with sufficient firmness, without at the same time allowing the white to show through it. Then for a medium between black and white, let the black weft enter into the ground and form plain cloth, passing the white weft to the back out of the way. For the lighter shades, or where it approaches white, simply let the black enter into the ground in some twill form, more or less of it entering into the structure of the cloth, according to the depth or lightness of the shade required, and



PLATE VII.

by this means we may obtain any degree of light and shade that may be needed.

Some splendid examples of this kind of weaving are exhibited in the well known book-marks of Mr. Stevens of Coventry, not only as illustrating the best methods of figuring with coloured yarns, but really as works of art. The use of coloured silks as well as of black and white is shown in many of these productions in the most perfect manner. Again, in the Paisley shawls, which were so extensively worn some years ago, we have some beautiful examples of weaving. In the fancy waistcoats of a by-gone day, and in some of the ladies' dress goods of the present time, excellent work is also displayed.

In Plate 7 we have a small portion of a pattern copied from a Paisley shawl, not by any means one of the most intricate designs, nor showing the greatest variety of colour, but sufficient to show clearly the principle. This is what would be called a "three cover," or "two cover and ground." There are two colours employed for figuring upon a white ground, the white itself taking some part in the formation of the figure. One striking feature of this design, as indeed of many of the patterns for this class of shawl, is that there is not at any point a great quantity of one colour either on the face or back of the cloth at once. This arrangement prevents the necessity for binding the loose material, although with the amount of figuring on the face the binding might be done without there being much probability of its being seen on the face; yet in light fabrics, such as the one from which this design is copied, it is better not to have to resort to it, but to bind by figuring. Although we may not bring any of the colours to the surface in large quantities at once, yet there is no difficulty in making predominate sufficiently at any part of the design to give character to it, as will be seen from the example before us. We have only to bear in mind the illustration we have previously made use of, of the succession of sounds conveying the idea of a con-

tinuous sound. A close examination of this pattern shows that the colour is in small patches, but at a short distance it has the appearance of being solid in colour. This is one of the most simple of patterns of this description, but it will probably be sufficient to convey to the student an idea of the manner in which they are formed. Very frequently a great many colours are employed, sometimes each colour being continuous throughout, at other times some of them "changing," and so giving greater variety. It would be an easy matter to multiply the illustrations infinitely, but probably most students of weaving will have opportunities of examining real fabrics of this description, which would convey more to their minds than any amount of writing.

In Plate 8 we have an illustration of a design for ladies' dress goods. It is a species of lace pattern upon the surface of the fabric, and was awarded the gold medal offered by the Worshipful Company of Clothworkers of the City of London at the Fine Art and Industrial Exhibition at Bradford in 1882. The designer of it, Mr. James T. Lishman, has kindly given permission for its use in this work. The pattern is formed by one extra weft and the ground weft combined; but though we speak of them as a ground and an extra weft, it would be difficult to say which we should have to call the ground, for both take an equal part in the formation of the cloth. The ground fabric is a satin with the warp on the surface and very closely set in the threads; this gives an opportunity for binding both wefts into the warp, and so imparting additional firmness to the cloth. Both wefts are lighter in colour than the warp, and thus the pattern is shown to the best advantage.

This pattern is an illustration of the fact that all our figuring material need not be the same; one is of silk and the other of worsted. Patterns are frequently made where the yarns are different in the materials of which they are made, and of the same or different colours. In some instances, as in the use of soft wool and silk to-

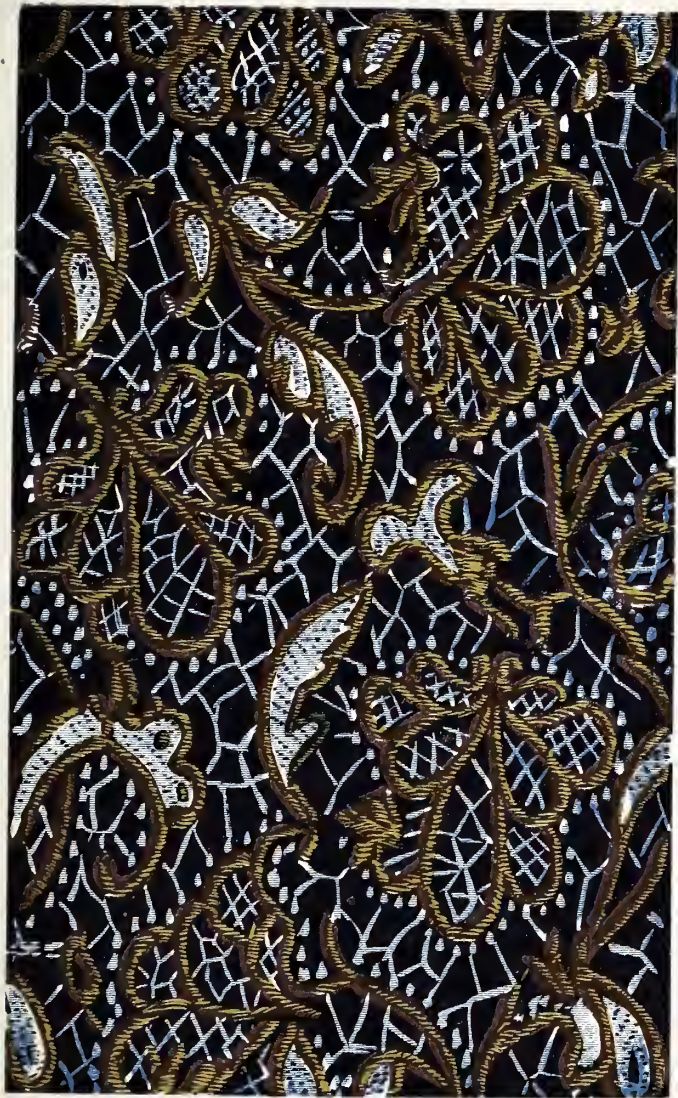


PLATE VIII.

gether, we may obtain very pretty effects, simply from the difference in the brightness of the material. If one be dull and the other very bright, the pattern will be distinctly visible, though both are of the same colour. Other instances might also be mentioned, such as the use of mohair, or alpaca and cotton in combination, and in all cases the effect of the pattern is dependent upon the brightness of one material and the dulness of the other.

84. Combination of Extra Warp and Weft.—We must now turn our attention to the production of patterns in which extra warp and weft are both employed, and a consideration of the reasons for using both.

One of the commonest forms of using both extra warp and weft is for the production of stripes with figures running between. Thus, for instance, if we were to take the pattern on Plate 4 where we have spots set some distance apart, and we wished to insert a stripe either between every figure or at alternate figures, that stripe would in all probability be of a different colour from the figures, and even if it were the same, it would be better and easier to make the stripe with extra warp than with weft. Then we have here not only one of the commonest forms of the use of both materials, but one which commends itself at once as being both a ready and economical mode of making such patterns. Of course this class of pattern is capable of an endless variety of arrangements; the stripes may be varied, and the figures also, and figure may be formed upon the stripe as well as upon the ground of the cloth by the extra material; and again in this, as in other cases, we may call in the aid of the ground material to give further variety to our figures. Another form of using both warp and weft is where we are figuring all over the fabric with extra weft, as in Plate 8, and we desire to introduce a small spot of a different colour, this spot to come in only at intervals. More force is given to this mode of working when our looms are capable of working with only a limited number of shuttles, and we wish to

use more colours than we have shuttles. In addition to that, where the spot *can* be as readily made with the warp, as we have previously pointed out, it saves time and expense in weaving, so that the designer will find numbers of instances where he can introduce a spot with extra warp, and add very materially to the effect of his pattern, without in a great degree increasing the cost. In such cases due care must be taken in arranging the pattern upon paper because of the distortion at the point where the extra warp comes in, caused by that warp being alternate with the ground.

Not only may we use extra warp for spots when we are figuring all over the fabric with weft, but we may also use both for figuring all over. Patterns made in this manner will have practically the same appearance as if two wefts had been employed; but there is this great advantage—that when they are not forming figure on the face, they may interweave with each other so as to form a cloth on the back, and prevent any loose material either from being cut off or bound into the face cloth, with the risk of showing through to the face.

Both warp and weft are used for the purpose of forming figures perfectly solid in colour, and of a texture quite different from the ground cloth, perhaps quite as frequently as for the purposes already named; and in such cases it is no uncommon thing for several kinds of figuring material to be employed upon the same fabric. We may use silk and worsted, or cotton and linen, or any combination, according to the nature of the cloth we are making, or the purposes for which it is intended. Whenever we figure upon this principle, we deal with the extra material as belonging to a second cloth; in fact, the principle of double cloth making is employed in its entirety. At the point where the extra materials interweave with each other, they form a cloth quite separate and distinct from the ground cloth; and if both are passing to the back at the same time—that is, if at any one point any of the extra warp is passing to the back,

and at the same time extra weft, which may be forming figure elsewhere, is passing to the back also—they interweave with each other, and so form cloth at the back of the fabric.

It will be easy to understand that by this system of working not only may we make the figures of any form, but we may introduce any number of colours also. If we make our warp in stripe form, and arrange the colours of the weft to correspond, taking care that any colour of weft always interweaves with the same colour of warp, and that the spaces occupied by each colour are equal to the spaces occupied by the figures they are to form, we shall have a series of figures, all different in colour but each solid in its own colour. Again, we may so arrange the colours of either weft or warp, or both, that each figure has more than one colour in it, and the colours may be mixed as we please; so that this mode of figuring gives us more scope for producing pretty effects, especially where we must have the figure displaying solidity of colour, than any other mode of working.

It is really an application of double cloth pure and simple in one sense. It is double cloth wherever figure is formed, but not necessarily all over the piece. If the two cloths were separated the ground would be one complete fabric, but not necessarily so of the figuring cloth—it would only appear in patches; and if the figures are formed from different materials, as silk and worsted, each material interweaving with its own warp only, we may be said to be using portions of three fabrics, but not more than two of them occurring at the same place.

But when we are figuring with extra warp and weft in this manner, we are not bound to confine them to interweaving with each other, but either or both may figure independently, and they may enter more or less into the ground cloth. In fact, we can combine in this one method of figuring *all* that we can do by *each* of

the other methods with which we have dealt, so that of all methods of figuring this one is the most comprehensive.

We have but one other mode of figuring to deal with at present, and that is what is known as lappet weaving. We shall subsequently have to point to other modes of ornamentation, but they will refer chiefly to special forms of structure in the fabric, and ornamenting by varying those forms of structure.

85. Lappet weaving is really figuring with warp threads, but presents to the eye the appearance of figuring with weft, very similar to swivel figuring. To convey an accurate idea to the reader of the true nature of this class of figures, it will be necessary to describe the mechanical method of producing the figure. From the warp beam the threads are brought forward towards the cloth; but instead of being passed through healds, in the usual manner, they are passed each through a needle in front of the reed or slay. These needles are carried in a vertical position on a horizontal movable bar. As a weft pick is being inserted the bar is raised, still keeping its horizontal position. The eye of the needle is near its upper extremity, so that as it is pushed through the warp which forms the lower half of the "shed," the threads which it carries are raised to the position occupied by the upper half of the shed, so giving room for the shuttle to pass under them. The moment the shuttle has passed through the warp the bar is lowered until the needles are quite clear of the warp; it is then moved horizontally to the right or left, and such distance as is required to form the intended figure; it is again raised, the weft inserted, lowered again, and the same operation repeated as before. By this method of moving the threads, a figure is formed on the *under* side of the cloth. This will really have to be the face; the cloth is woven wrong side up. The figuring material is bound into the fabric by being passed round a weft thread, always entering and issuing from the cloth

between the same warp threads, but not between the same weft threads. Figures of this description are easily distinguished from "swivel" figures, or any figures formed by weft. In forming weft figures the thread does not necessarily "float" on the surface the entire width of the figure, but may be bound into the cloth at any point, or any number of points, either for the purpose of preventing looseness or for producing given effects, such as the veins or stems of leaves or flowers. But lappet figures cannot be so bound; they must "float" the entire length of the figure, consequently the figure must be of a simple character, and present an appearance of solidity. An appearance somewhat approaching that of a "swivel" figure may certainly be produced by letting the thread forming the figure enter the cloth at some point in the middle of the figure, but a pick of weft must be inserted before it again issues from the cloth, so that it will present the appearance of two threads, not of one thread having simply been bound into the cloth by passing under warp.

Lappet figures are not usually made very large or in masses; they generally are of a scroll character, showing only thin lines, such as would be produced by a thread stitched into the cloth at intervals, so as to form some simple pattern, similar to that shown in Plate 9, Fig. 16, and referred to at page 188. Of course it must be understood that the threads for figuring are not set so closely as the ground warp, but at intervals of an inch or so, according to the size and arrangement of the figure.

This method of figuring has peculiar advantages, and some disadvantages. As compared with "swivel" weaving, it uses just the quantity of material required to form the figure as the swivel does; but the figure cannot be bound into the cloth in the same way, and consequently cannot give the same effects. On the other hand, the figures can be set nearer together, in fact, as near as we please; we need not consider the size of the shuttles. And

again, we have not to pass a shuttle through the warp for the sole purpose of forming the figure ; the ground weft binds in the figuring thread, just as in ordinary warp figuring, so there is economy of time and labour.

86. The allotment of Area to Figures.—We have now dwelt generally with all the ordinary methods of figuring on fabrics, and also to some extent with the effects upon their structure, but we must take into consideration the areas to be occupied by figures of different descriptions, not so much in reference to the ornamental or decorative effect intended to be produced, as to the effect upon the texture of the cloth and its application to useful purposes. If we are making figures by allowing the material which forms the ground of the cloth to cease to interweave and simply lie loosely one upon the other, it is very obvious that we cannot carry the figuring to any great extent without very materially impairing the structure of the fabric and affecting its utility. We have already shown the necessity for perfect distribution, and the question of the proportional area which the figure must occupy in relation to the ground ought always to accompany that of equal distribution. To lay down hard and fast lines, definite rules, would be impossible ; we must be guided in the first instance by the uses to which the fabric is to be applied, and in the second place by the order of interweaving of the ground cloth.

No matter what may be the structure of the ground cloth, if the figuring occupy a considerable portion of the surface we must alter the quantities of warp or weft, or both, because the want of structure at the points where the figure is formed will very materially affect the whole fabric, so that we cannot separate one consideration from the other. In fact, we must treat it somewhat as we treat twills, whether plain or fancy. As we have made the fabric loose in its texture by the order of interweaving, we must compensate for it by the increase of material, so that one set of threads can give the proper amount of support to the other.

As we have seen, when figuring on the principles of diaper or damasks, we need not take the areas into account as when the figures are loose, for the texture of the cloth is not altered; it remains the same throughout, and our figures may occupy any space, or come as closely together as we please. The same may be said of figuring with extra material, provided sufficient precautions have been taken to bind the figure on the face, so that the "floats" are not too long, or so that they do not appear as so much loose material on the face of the cloth. In figuring with double cloths we are much in the same position as with diapers and damasks; no matter what extent of figuring we have, each weft continues to interweave with its own warp; there is no loose material, but always a solid fabric. If the figures be very large, however, it may be necessary to bind them together in the middle of the figure, if formed of two separate cloths, else they would separate from each other, and give the cloth a flabby character; but if it is simply a double faced cloth the binding goes on the same throughout. These considerations of allotment of area and the effects upon the fabric are such as must be dealt with as they arise, and as the circumstances of the case may necessitate, and not by any arbitrary rules, which could not apply in every case alike. The designer having made himself thoroughly familiar with all the various structures of cloth, with the relative quantities of warp and weft necessary to give a perfect fabric, and with the conditions and circumstances which will tend to destroy this perfection, will find little difficulty in counteracting these conditions as they arise.

CHAPTER VII.

GAUZE FABRICS.

87. **The Structure of Gauze.**—We may now turn our attention to fabrics of a totally different character from those with which we have been dealing, and consider not only their structure or their decoration, but the decoration by variation in the structure. We have yet several classes of fabric to examine, all of which present certain inherent peculiarities in their structure, and these forms of structure we may combine with those we have already considered for the purpose of ornamentation.

We will first deal with gauze and its varieties, and examine into the structure and methods of ornamenting. The whole structure of gauze cloth is quite different from any other and most nearly approaches lace. The fabrics of which we have been treating up to now, whether plain or figured, have all the warp threads parallel to each other, and the patterns are produced by the order of interweaving. In gauze the warp threads are not parallel, but twist round each other more or less, and the pattern may be formed either by a variation of the order of twisting, or by their ceasing altogether to twist, and forming figure after the manner of cloths with which we have dealt. We will endeavour to discuss this subject in the most exhaustive manner possible, and show the combinations with other orders of weaving, but it will be a difficult matter to put the subject before the student in such a way as to elucidate all the uses and applications of gauze weaving. We can only hope to give the general principles, and show very briefly how we may combine with other orders of weaving for the production of patterns.

Since the introduction of the Jacquard machine, gauze, like other classes of goods, has been very much improved, at least so far as its combination with other orders of weaving is concerned. On the other hand, the introduction of the lace frame, and the consequent cheap production of lace, have caused some of the most elaborate forms of gauze weaving to become obsolete. Murphy's excellent work on the "Art of Weaving," shows some most beautiful patterns of fabrics which have been quite superseded by lace, and which are probably not made, or anything approaching them, at the present time. Perhaps the introduction of power loom weaving—upon which, so far as they are perfected at present, such fabrics cannot be woven—may have had something to do with this, but cheap lace has probably had more. On the other hand, the combination of gauze with other orders of weaving, as it has been developed within recent years, gives much more beautiful patterns than the most elaborate gauzes of former days, though, perhaps, not so ingenious in the structure of the cloths.

We will first deal with gauze in its simplest forms, and show the various methods of producing patterns, and then proceed to the more elaborate combinations.

Plain gauze has all the warp threads divided into pairs, the threads of each pair half twisting round each other between each weft thread. The plan in Plate 9, Fig. 1, is one of plain gauze. An examination of this plan will show that one half the warp is always under the weft, and the other half always over it; the thread which comes uppermost always passing under the other between each weft pick, and consequently coming up on one side and then the other alternately, so that the fabric is held together solely by this crossing of the warp threads. If the straight thread were drawn out of the cloth, the crossing thread, or that which comes to the surface, would simply lie perfectly loose upon the weft, no interweaving whatever taking place. In fabrics made

upon this principle there must of necessity be very great firmness of structure; the twisting of the threads round each other, and holding of the weft in their coils, as it were, must give a very strong texture. At the same time, the crossing of the threads between the weft picks will not permit these picks to come close together. Suppose we hold what we for convenience call the straight thread—that which never comes to the surface—perfectly tight, and allow the crossing thread to go comparatively slack during the operation of weaving, so that the crossing thread has not only to bend round the weft but also round the straight warp thread, each weft pick will be kept apart for a space just equal to the diameter of the warp thread; but if both threads are held equally tight, then, as each successive weft pick is driven up to the cloth, both are equally bent out of their course and the twist occurs exactly between the picks, thus keeping them a distance apart equal to at least the diameter of both threads.

In the event of the threads being held at an equal tension in this manner we have a more open texture and, at the same time, a firmer one. When one thread is quite straight and the other bends round both it and the weft, the weft cannot be so firmly held between them as when the crossing thread is so tight as to draw the other out of its straight line.

Of all fabrics there is none so firm in texture or so light in the quantity of material it contains as plain gauze. It cannot be made into a very bulky cloth, and the order of interweaving prevents it from being made a close, compact cloth. It will always present a perforated appearance, and increased thickness of threads, more especially of warp, will increase the size of the perforations.

88. Figuring with Plain Gauze.—We must now proceed to deal with the ornamentation of gauze fabrics; and so as to deal most effectively with the subject, we will first examine the various methods of crossing and

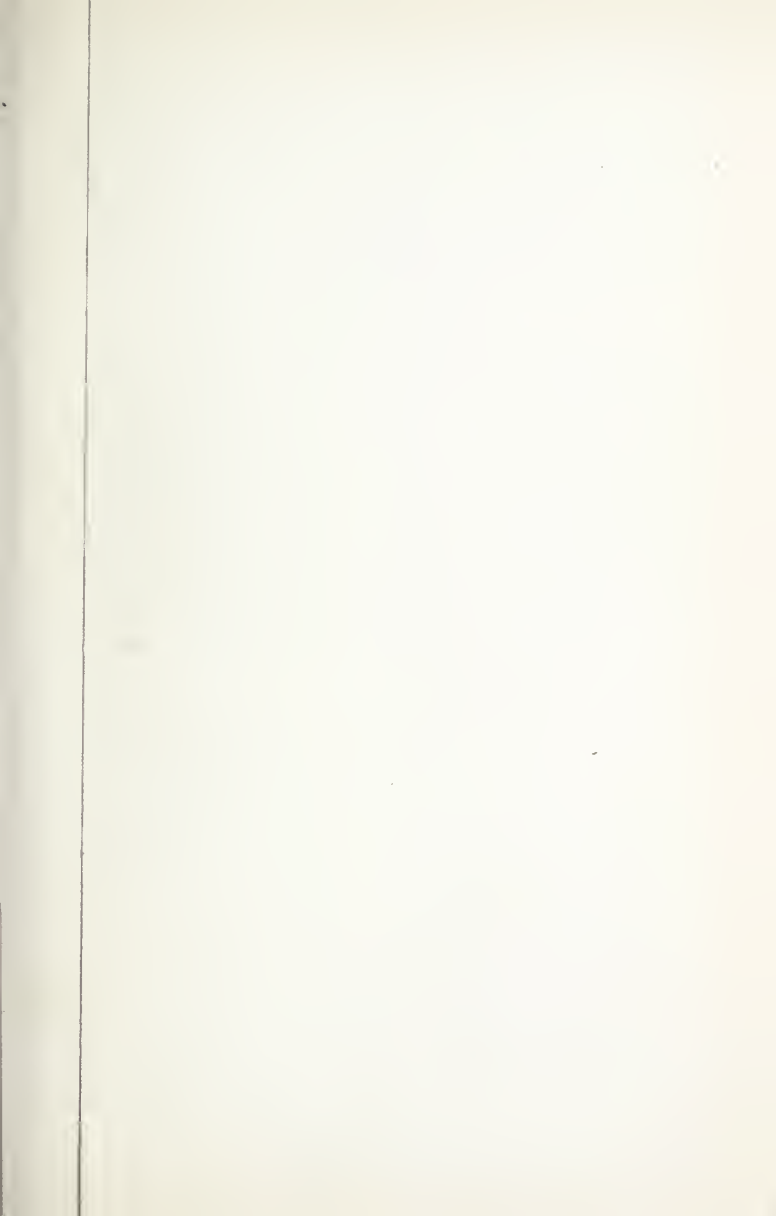




FIG. 1.



FIG. 2.

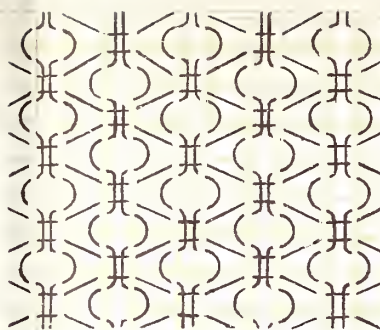


FIG. 3.



FIG. 4.



FIG. 5.



FIG. 6.



FIG. 7.

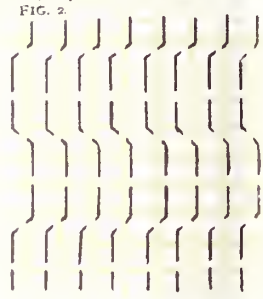


FIG. 8.

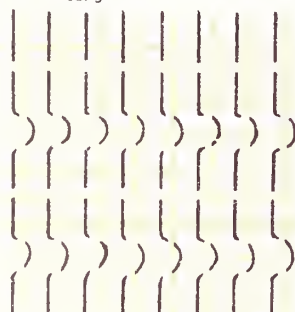


FIG. 9.

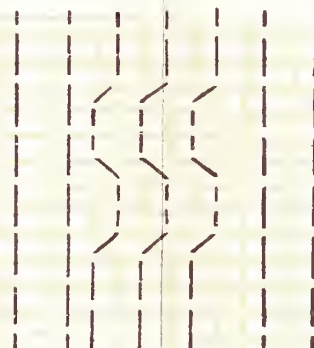


FIG. 10.



FIG. 12.

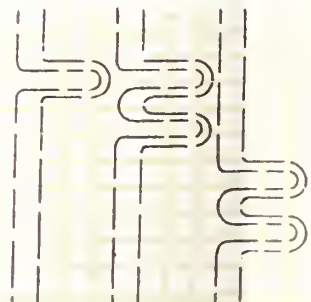


FIG. 13.

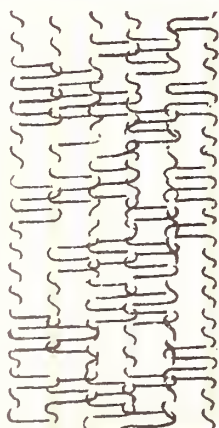


FIG. 19.



FIG. 17.



FIG. 16.



FIG. 15.



FIG. 14.

FIG. 18.

interweaving, and the reasons which may induce us to adopt them. We have shown in Plate 9, Fig. 1, a plan of plain gauze ; of this we may produce some varieties. If, for instance, we have every alternate pair of threads crossing in opposite directions, that will give a slight variation, but it will be more effective if the weft thread be very thick ; it will throw it up as though it were a series of small spots. Again, further variety may be given to it by using thick and thin weft alternately, or by using a given number of picks of one thickness and a number of another ; or other similar means may be resorted to for the production of special effects. Again, a further variety of plain gauze may be made by having two pairs of threads crossing in one direction, say, from right to left, and at the same time two pairs crossing in the opposite direction. It may seem absurd to speak of forming patterns with plain gauze, but what we mean by plain gauze is where one end crosses one, and that at every pick, the mere reversal of the direction of crossing, or the use of threads of various thickness, although it produces pattern, still leaves the structure of the cloth equal to that of a plain gauze, so that we speak of it as such, but when we vary the order of crossing, then it may become a *fancy* gauze.

A very pretty example of figuring with plain gauze, by reversing the crossing, and in which weft threads of different thickness are used, is shown in Plate 9, Fig. 2. Although in the order of crossing, with the exception that they are reversed, the cloth is quite plain, yet the combination of this reversal with the different thickness of the weft threads produces quite the effect of a figure.

89. Figuring by various orders of Crossing.—In a great many instances of the production of patterns by varying the order of crossing, a number of weft threads are allowed to come together so as to form one ; they then separate, some of them after separation continuing single for some time, then rejoining the group, others leaving one group to form part of another, and so by

varying the division and bringing them together at different points forming a distinct pattern. An example of this mode of working is shown in Plate 9, Fig. 3.

This method of figuring, as may be seen, is capable of great variation, and, as compared with plain gauze weaving, will give more weight of fabric; for while in plain gauze every pick is kept quite distinct, whether we reverse the crossing or otherwise, in this mode of figuring more picks run together to form one; and although they may separate and form part of other groups, yet the fact of a number of picks running together, even at different points of the fabric, will permit of a greater number of picks per inch being inserted, and so give more weight to the cloth.

In addition to the mere formation of patterns in the gauze in this manner, we may combine any two or more of these orders of working for the production of stripe check or distinct figured effects. For instance, we may take the patterns shown in Figs. 1 and 3 (Plate 9) and form a stripe with them, or in like manner any two workings or patterns; but there is one thing we must very carefully observe in doing so. We say that Fig. 3 will permit of a greater number of picks per inch of the same yarn than would Fig. 1. If that be so, and we combine them together in stripe form, we cannot put as many picks per inch into the cloth as will make the stripe formed of Fig. 3 pattern perfect without at the same time forcing too many into that formed with Fig. 1. Indeed, what will most likely happen will be that the plain gauze stripe will not permit the number of picks being inserted which can make the other perfect; and even if it did, the warp forming the plain stripe would become very tight as compared with the other, and the gauze would not have a sufficiently open and perforated appearance as compared with the fancy one. Then we must adopt some means of counteracting this; we must have both stripes equally perfect in their structure. We may easily do this by allowing two or more picks—ac-

cording to the pattern of the fancy stripe—go to form one of the plain gauze. By doing so we can bring both to the same density of structure very readily, and also give more openness to the plain gauze.

It would be an easy matter to give a great many patterns of gauze made upon this principle, and some of them very nearly approaching the appearance of lace, and if we were writing a history of gauze we might show some most excellent and elaborate patterns produced in the days before the lace frame made such progress; but at the present time their manufacture could not be carried on profitably.

90. Combination of Gauze with other Orders of Weaving.—It is not so much in producing pattern by variety of crossing as by combining gauze with other forms of structure that such fabrics are made at the present time, and in this we may manufacture fabrics which do not come at all in competition with the lace or net goods.

We will endeavour to deal with all the most general combinations, and show both the method of forming patterns and the chief characteristics of each kind of combinations.

We will begin by taking those combinations which most nearly approach pure gauze, and which are, in fact, intended to convey to the mind the idea of pure gauze, and at the same time produce a heavier fabric, with more marked perforations, without making them actually coarse by using thick yarn.

If we refer to Plate 9, Fig. 4, we have a pattern which is a combination of gauze and plain cloth, but which presents to the eye the appearance of pure gauze. The warp is divided into sets of four threads, and in the crossing two of those threads cross the other two; at the same time there are four picks of weft which appear to go in as one. But those four picks are effectually separated by one pair of ends out of each alternate set interweaving with them as plain cloth, and the next

set of four picks weaving plain with two ends of the next set of warp ends; the result of this plain weaving being that, instead of the four picks which go into the cloth apparently as one, forming a thick rope, as it were, they are spread out and laid side by side, and form more of a ribbon-like structure. The effect of this, both in the appearance and in the structure of the cloth, is much better than if the four picks had gone in absolutely as one. The gauze effect is quite as good, the perforations being clearly marked, and the cloth is somewhat stronger, without appearing quite so bulky. In some instances, where it is desired to spread the weft even a little more than is done in the pattern before us, two of the four threads would weave plain with one set of four picks, and the other two with the next four. This would make the cloth a little firmer again, and prevent any possibility of any of the picks getting too close together or one on the top of another. A very simple and effective method of combining gauze with plain is shown in Plate 9, Fig. 5, where two or more threads are weaving plain with the weft all through the piece, and a thick figuring end, as we might term it, is forming gauze by crossing and recrossing round the ground ends. In this pattern the effect is somewhat similar to that of the previous pattern, but the thick gauze thread gives it a good effect. Again, sometimes the gauze thread weaves plain into the ground along with the other ends, and then crosses round them, as shown in Plate 9, Fig. 6.

In all the patterns we have shown so far all the crossing threads are crossing at the same time, so that the division between the picks is all across the piece. Certainly some of the threads are crossing in opposite directions at the same time. Even by this method of working we may produce some very pretty effects.

The patterns shown in Figs. 2, 3, 5, and 6 (Plate 9) would have somewhat the appearance of net. The perforation would all run in straight lines, but the threads would be drawn out of the straight line, and by some being

drawn to the right and others to the left, a distinct net pattern would be formed.

Although such patterns may be very pretty, much better effects may be produced by varying the crossing; that is, by not letting all the threads cross at the same place. Take, for example, Plate 9, Fig. 7, in which the crossing threads form a distinct pattern. Another very good specimen is given in Fig. 239, p. 250, of my "Treatise on Weaving and Designing," 2nd Edition; and did our space permit we might give numbers of illustrations all showing patterns of gauzes crossed in different manners, and producing some of the most beautiful effects in the fabric.

When we have obtained all the patterns we can in the gauze, though they make pretty fabrics in themselves, we may treat them as the basis for further ornament. We may combine any two of the different orders of working, and produce stripe or other patterns, or we may figure upon the gauze grounds, or form figures of gauze upon plain or other grounds.

We have already shown the combination of plain with gauze in one simple form. Before entering too fully into the question of figuring with gauze, we may examine a few more simple combinations of a different character. Sometimes the introduction of gauze into a fabric is not so much for the purpose of ornament as to obtain lightness of cloth or openness of texture, and, as we have already shown, there is no better means of obtaining light open texture combined with strength than the use of gauze, and by combination of gauze with plain or other orders of working we may regulate the weight and bulk of the fabric. Take the example shown in Plate 9, Fig. 8. We have three picks of weft weaving quite plain, then a crossing takes place in the warp; there are three more picks of plain, and another crossing takes place. Now this cloth is as nearly as possible a plain one, the crossing which takes place is not what is termed a full gauze, but only a "half-cross;" that is, after the

crossing thread has changed from one side to the other of the straight thread it remains there for some time before crossing back again, all the time weaving plain with the weft. That being the case a division takes place, or the weft threads are held apart by the crossing of the warp threads at every three picks. This division will be equal to at least the diameter of the crossing thread of warp, and it will certainly be greater than that between two picks of the plain portion of the piece, and will therefore show an opening or "crack" all across the piece; consequently there will not be as many picks per inch as if this crack did not exist, and as a matter of course the more frequently these cracks occur the less weft the piece will contain. Sometimes what is termed a full gauze pick is introduced; that is, the warp crosses on both sides of one pick of weft, as shown in Plate 9, Fig. 9, the distances between the gauze picks being varied according to the weight of cloth required, or the effect desired to be produced.

If we wish to combine plain cloth and gauze in stripe form, we must consider the relative structure of the two cloths. We will suppose in the first instance that we wish to have a stripe running the length of the piece plain cloth and gauze alternately, and we have the same number of threads per inch in both. The plain portion will be a very loose fabric and the threads would slip upon each other and fray; that being the case we must either have a greater number of ends per inch in the plain stripe, or adopt some modification in the gauze. If we increase the number of ends in the plain stripe, or the diameter of the threads of which it is composed, or, what would be better, combine the two alterations, we may make it sufficiently firm, but we shall have increased the weight very considerably, and it is not desirable that there should be such a great difference in the weight of two portions of the same fabric as would necessarily accompany this arrangement; then we must resort to the expedient of altering the

gauze so as to enable us to put more weft in. This may be done by simply letting a number of picks go into the gauze as one. Suppose, for instance, it should require sixty picks per inch in the plain cloth to make it such a cloth as we require, we could not possibly put sixty of such picks into the gauze portion, with the warp threads crossing between each one; but if we allow two, three, or four of these picks to go into one shed between each crossing, then we can get them in quite easily. If two picks go in between each crossing, it reduces the number of crossings to one half, and the two go together to make one pick, and consequently occupy much less room. The most common practice is to put three or four picks together, but this will be regulated by the quality and weight of cloth required.

If the stripes are to be across the piece, then a different mode of working must be resorted to. We may, perhaps, put more than one pick together in the gauze, so as to give more decision to the perforations, but we must alter the warp threads. We have up to now been speaking of the gauze ends as single in the warp, but we may put any number together. Suppose we want our plain stripe to be finer than the gauze in the proportion of two threads to one; then when we are weaving the gauze, two threads go together as one, and the gauze shows two threads crossing two, but the moment we begin to form plain cloth they separate and work independently of each other. This method of altering the gauze, putting a number of threads together either in the warp or in the weft, or both, is the most ready and efficient for forming either stripes or figures. If in making patterns which are combinations of gauze and plain cloth we do not desire to have quite so much or so striking a difference as is shown between gauze and plain, the gauze having a number of threads together, both in warp and weft, we may obtain a medium between the two.

We have in Plate 9, Fig. 10, an illustration of one mode of dividing the threads of weft after they have

combined to form gauze, and also of intermixing plain in the gauze, and making that which is so intermixed different from the ordinary plain cloth in appearance. For the purpose of illustrating this most clearly, we have shown it as really forming part of a check pattern instead of a stripe; that is, with plain cloth all round the gauze.

The system of forming pattern in stripes or checks, by the combination of gauze and plain cloth, such as we have been dealing with, may strike the reader as being extremely simple. So it is. There is no more simple method of forming patterns upon light fabrics, or of ensuring the lightness of the fabric, and at the same time producing very pretty effects; but in the decoration of gauze fabrics, or using gauze for the decoration of fabrics of other structures, the stripes or checks are the most simple, though even they are capable of giving very great variety, especially if threads of different thicknesses be employed, or if there be a variation in the number of ends and picks which are put together.

91. Figures formed by Combination of Gauze and Plain Cloth.—Though we can produce great variety by combination of gauze and plain in these two forms, we have far more scope when we begin to form figures with them. There may be said to be two distinct methods of combining these two orders of working to form figures: first, figures formed by plain cloth upon gauze ground; and second, figures formed by gauze upon plain ground. We will examine both in detail, so that we may see to what class of fabric each is applicable. If we are making a plain cloth, and we wish to form patterns upon it by giving it the appearance of being perforated, we may introduce gauze working to form the perforations, and by doing so give lightness to the cloth without detracting from the firmness of structure, but rather adding to it. Take, for example, the small pattern, Plate 9, Fig. 11, where we have every alternate pick of weft forming gauze at some point, and the gauze being distributed regularly over the surface of the fabric. As it appears

on the diagram, each of the weft threads forms straight lines, the warp bending round them at the point of crossing. This is shown so for the purpose of giving a clear view of the structure of the cloth; but in the actual fabric the weft threads would not form straight lines, but on each side of the gauze crossing would curve round, disclosing a distinct perforation on each side of the pick, and the thicker the warp threads the wider will the perforations be. The pattern we have here is one which in the cloth would convey the impression of the gauze and plain being in about equal quantities, although really only one-fourth of the interweaving is gauze, but the plain picks are so much bent out of their straight line, and jammed together by the crossing of the warp, that they occupy less space than they otherwise would. This will prove, then, that greater firmness is obtained in the cloth by the introduction of the crossing than if it were all plain. If the weft threads can be so much bent out of their straight line, and, as it were, pushed closer together by the gauze, they cannot be so firmly interwoven with the warp; the relative quantities or thicknesses of warp and weft threads cannot be such as to make a satisfactory cloth, were it not for the presence of the gauze. These remarks will apply all the more if the weft threads are soft; that is, loosely twisted together or made of soft materials.

We have in this pattern a medium between pure gauze and plain cloth. It contains more material, is closer in texture, and heavier than if it were pure gauze, but not so close, compact, or heavy as a plain cloth. It presents the chief characteristics of the gauze, with some of the qualities of a plain cloth, or, in other words, it has the decorative features of gauze with the wearing properties of plain cloth. If we wish to make the perforations more marked, we can easily do so by letting the crossing take place with more than two ends; that is, let two ends cross over two, or more; or, let a number of picks go together to form one in the gauze.

By resorting to either expedient we may have the plain portion both closer and heavier, and the gauze portion quite as open, or even more open, than in the combination of simple plain gauze with plain cloth.

We must, however, consider the character of figure most suited to this class of fabric, and the effect upon the cloth. An examination of a figured gauze will immediately reveal the fact that where the crossing of the threads takes place, a greater length of warp yarn is taken up than where there is no crossing, even in a small simple pattern like that shown in Fig. 11 (Plate 9), but if the gauze be further extended it will be even greater. In fabrics consisting of a combination of plain and gauze, for the most economical production, the whole of the warp should come from one warp beam. Such being the case the gauze must be distributed as equally as possible, so that one portion of the warp, by reason of a greater amount of gauze being formed with it, shall not become tighter than the rest. Then, if we are forming spots, they must be very equally distributed, so that every thread has its equal share in the formation of gauze. Again, the figures must not be too large, or occupy too much space at once, and the gauze must be considerably less in quantity than the plain, otherwise the plain portion of the cloth will be too thin, and the threads will be too loose upon each other.

92. Distribution of Gauze Figures on Plain Ground.

—We have already pointed out in reference to spot figures what is the best method of arranging the spots so as to secure equal distribution, and what was said there will also apply equally to gauze spots, and it is even more imperative that the rule should be observed than in ordinary warp or weft spots, so as to secure uniformity of texture. But we may not always desire to produce spot figures; it may be that we wish to have figure or gauze working running all over the fabric, in fact, to imitate to some extent lace; then we may adopt scroll patterns, or any other which will give such effects as we

wish to produce. If we do adopt such figures we must be extremely careful in their arrangement, so as to ensure equal distribution. We shall generally find that geometrical designs are best adapted to this class of figuring, not necessarily of the stiffest character. We may introduce some freedom of design, but if we have a geometrical basis we shall be more certain of obtaining equal distribution. Of course, we are speaking now of the combination of pure gauze; that is, one end crossing one, and only one pick between each crossing, with ordinary plain cloth, and the gauze forming the figure.

93. Plain Figures upon Gauze Ground.—When the figure is formed by plain cloth upon gauze ground, the conditions of the structure are different. We obtain only a very light cloth if the warp threads are one crossing one and at every pick. The mere fact of so much crossing taking place—the greater part of the fabric being gauze—will necessarily make it a light open fabric; that being the case, any figure formed by plain cloth will be very loose. No matter whether the figure be large or small this will apply; but it would of course be more apparent in large than in small figures. If extremely light fabrics are desired, this mode of figuring may be resorted to, and some very pretty effects obtained; but as in the case of gauze figure upon plain ground, there must be very perfect distribution, and if the figures are so small that the pressure of the warp in the crossing can push the weft picks a little closer together in the plain, the appearance may be very much improved, for not only will it make the plain look finer, but the curvature given to the weft threads will give a more novel effect than if they were quite straight and parallel to each other.

It may be observed of gauze cloths, as differing from all other woven fabrics, that instead of keeping the threads of either warp or weft parallel to each other, the object very frequently is to draw them out of their parallelism as far as possible.

94. Warp or Weft Figures upon Gauze.—This com-

bination of gauze and plain is the most simple form of ornamenting gauze fabrics, no matter which of the two predominates or forms the ground. In addition to this system of figuring we may also resort to warp or weft figures, as in ordinary fabrics, but we must not be under the impression that when we do so we can figure as readily and with the same results as figuring on ordinary fabrics.

In the first place, if our ground cloth be an ordinary plain gauze, of the type of which we have been speaking, and we suddenly cease to form gauze, and leave the weft and warp quite free of each other, neither of them would be present in sufficient quantity to cover the other. And as it is usually one of the first conditions in figures that the material which comes to the face shall quite cover that which goes to the back, so as to present a solid appearance, it could not give a satisfactory effect if the warp and weft were both visible, one through the other, in the figure. Again, the sudden transition from gauze—the firmest possible structure of fabric—to absolute looseness, the warp and weft not interweaving at all, would be too great. If we wish to have either warp or weft figure upon gauze ground, we must separate the figure from the gauze by plain cloth. This will to some extent modify the looseness of the figure, and, what is quite as important, it will give it most clear definition. If we were to change direct from gauze to figure, the figure could not be clearly defined, especially if it were large, and its outline at all indented; but by bringing in the plain all round it, it is formed just as upon an ordinary plain fabric. Another question arises also; the figure must in all probability be bound down more or less. This binding will be more in harmony with the ground surrounding the figure if it be plain than it would be if gauze. We still, however, have the difficulty of want of fineness, not only in the plain which surrounds the figure, but more especially in the figure itself. If the figure is to be formed with the weft, we may resort to

the expedient we have before mentioned — namely, putting more than one pick of weft in one shed; and this we may vary according to the size of the figure or quality of the cloth. By doing so we shall not only make the figure “cover” better, but we shall add to the fineness and firmness of the plain portion without detracting from the openness of the gauze. If the figure is to be formed with warp, we may make a number of ends work together in the gauze, and then separate them in the plain, so making sufficient fineness, and making the warp figure cover the weft. We may also combine the two methods, a number of ends going together as one, and a number of picks going together as one in the gauze, thus increasing the fineness of the plain and the weight of the cloth to any degree, without interfering with the openness of the gauze, unless it be to make it more open. To begin with, suppose that we only want to increase the fineness in a slight degree in the warp, and to obtain the requisite increase of ends we let them work in groups of three, one crossing two—that is, one end working by itself, and two working as one along with it when forming gauze, but separating for plain, as shown in Plate 9, Fig. 12.

When the crossing is of this description, the crossing threads may go all in one direction, or they may cross alternately in opposite directions, as shown in the figure; but in either case when they separate they must form perfect plain cloth. In arranging designs upon the squared paper for this kind of crossing, perhaps more care is required than for any other kind, because the gauze threads being arranged in threes, and the plain having alternate ends alike, or, as it were, working in pairs, each end must be properly arranged, or a fault will occur in the plain. Now, if we form warp figures with the ends arranged in groups of three in this manner, and we do not separate the figure from the gauze by the introduction of plain, our warp threads will be laid in groups of three, which will look like one thick thread.

Our object must be to distribute the threads; then we have no alternative but to introduce some plain so as to effect this separation and distribution. The more general practice in figured gauzes is to arrange the threads in groups of four, two threads together as one throughout, and crossing each other in pairs, as shown in Plate 9, Fig. 13, and separating to form plain as before. This has the double advantage over working with three threads of making the cloth still finer, and giving us even numbers of ends to deal with at once. In such cloths, however, the mere increase in the warp threads is not enough usually, we must also increase the weft threads by putting two, three, or four together in the gauze and separating them in the plain. Now, in many instances we may desire that our figures should be not merely loose warp or weft on the surface, but, perhaps, bound in satin order, after the manner of damask or such figures, so that it is absolutely necessary to obtain fineness in the figuring portion; but no matter how the figure may be formed, the almost invariable rule is to surround it with plain, so as to ensure the proper separation of the threads before the figure is formed. This plain need not be more than a few ends, but it must be there. Another feature of gauze figures is that a true even outline cannot be formed as in patterns upon plain or satin ground, the threads running together in groups of, say, four; all these four will cease to form gauze at the same time. One portion cannot be making gauze while the other portion is making plain or figure, therefore the outline will form a series of steps, not a steady, free line. This difficulty is even more apparent in flowing curves, the steps interfering very much, in some instances, with the beauty of the curve, and requiring the utmost care in reducing the interference to a minimum.

Perhaps it will not be out of place here to say a few words upon the mechanical operations required in gauze weaving. Our excuse for doing so must be that existing treatises on weaving do not deal in a sufficiently

complete manner with the subject, as applied to the looms of the present day.

The general principle of gauze weaving is fully treated in the "Treatise on Weaving and Designing" before referred to, so far as the formation of gauze in small patterns and stripes is concerned; and more fully in the excellent treatise on the "Art of Weaving," by John Murphy. But Murphy's book was written before figured gauzes of the class now mostly used were developed by the Jacquard machine, which was at that time quite in its infancy; and, again, most of the fancy gauzes of which he treats are such as could only be woven in the hand loom by careful weavers, because of the complication of cordage, and the delicacy of manipulation required; and besides, such goods have been entirely superseded by the lace frame.

In the "Treatise on Weaving and Designing," the use and construction of the doup heald are fully explained, as also the use of several douns along with healds for forming patterns in the gauze, but nothing is said of Jacquard harnesses for weaving figured gauze. If all the doup healds are attached to one heald shaft it will be obvious that they will all rise together whenever that shaft is raised; and if we use two or even three heald shafts for the douns, it is evident that our orders of crossing will still be limited. But even limited though it be, under certain conditions we may make great variety of patterns; for instance, such patterns as that shown in Plate 9, Fig. 11, can be woven quite easily, either with healds, or a common Jacquard harness and one doup. Although all the ends are not crossing at the same time, the crossing end is drawn through the doup and through one of the ordinary healds at the same time, but is carried under the thread with which it works *between* the common heald and the doup, so that as the common heald rises, it will take it to one side of its companion thread, and when the doup rises it will take it to the other side. Now, if we have half the threads drawn

through the doup heald, and each through a separate common heald, so far as the pattern goes—as, for instance, in the pattern before us, there are eight separate threads—we shall require eight common healds, each thread drawn through one of them, and the first of each pair also through the doup. If the ends are crossed from the common heald to the doup, from left to right, whenever we raise the doup all those ends will rise on the right of the threads they cross; then if the pattern is to be a combination of gauze and plain, as in this case, we lift the doup at every alternate pick of weft; and if we wish to form gauze at the next pick we raise the common heald carrying the crossing thread, so bringing that thread up on the left of its companion, as shown in the figure; and if we wish to form plain we raise at the second pick the thread which *does not* go through the doup. If we now substitute for the eight common healds, a Jacquard machine, where we can actuate each thread separately, and we place in conjunction with that a doup heald, and draw the ends through the doup in the manner described, it is very evident we can produce any variety of figure which is a combination of plain cloth and plain gauze, or we may make warp figures upon the plain, or further, we can combine plain gauze with twill, or make one end cross three or any number; but if gauze is forming at some point throughout the piece we are necessarily confined to one pick in a shed, and to one end crossing at once, and all ends which do cross must cross at the same time and in the same direction. True, we may give some variety by using more than one doup, but still we should be confined to certain classes of figure; then if we wish to figure freely, and at will, we must resort to what is known as a gauze harness—that is, with douns formed in the harness of the Jacquard machine; this provides that each set of threads has its own separate doup, which may be brought into use at will, so enabling us either to vary the direction of our crossing, or the number between each crossing as we please.

95. Combination with other Orders of Working than Plain.—We may now proceed to examine a little more in detail the combination of gauze with other orders of weaving. We have shown pretty fully how it may be combined with plain, and how the fineness of the cloth may be increased to almost any degree, and also, to some extent, how figures may be formed with warp or weft, or both. When we are figuring upon a gauze ground, we may vary both the form of the figure and the order of interweaving of the weft with the warp as we please, provided, as we have already said, we surround the figure with plain, so as to prevent the gauze from interfering with the outline, and the ends from running together in groups. Having done that, we are as free to figure or introduce twill, satin, or any other order of working, for the purpose of obtaining special effects, as if our cloth were an ordinary one with no gauze in it. Not only that, but we may vary our gauze; we need not necessarily keep to the plain form of gauze working, either with single threads or a number thrown together, but we may adopt any of the forms of gauze such as those shown in Plate 9, to make the ground-work. It is not necessary that we confine ourselves to the gauze forming the ground of the cloth. Very frequently we may desire to produce a somewhat heavy cloth with a simple twill or satin ground, and in order to give a light appearance to it, we may introduce a gauze figure. Or the ground may be a figured one, such as a rich damask, in which case a small portion of gauze introduced into certain parts of it will give lightness; by this means some of the richest and most beautiful fabrics are produced. We often see in silk goods that some of the choicest fabrics are combinations of this character; in fact, there is no limit.

Quite apart from the combination of gauze with plain or warp or weft figure, we may also produce excellent effects by combining two orders of gauze working, one forming the figure upon the other, but, of

course, in such cases the cloth must necessarily be a light one ; and if one portion of the gauze be much firmer than the other, the remarks which we applied to the combination of gauze with other orders of weaving respecting the proper distribution will apply to it also.

Having examined the combination of gauze with plain to form figures, we may now examine the combinations with other orders of weaving, for the production of effects of different characters. We have already referred to the formation of plain stripes upon gauze ground, and pointed out the necessity of either putting a number of picks together in the gauze, and separating them for the plain, or having a greatly increased number of ends in the plain stripe. In many instances the latter arrangement is preferable ; by increasing the number of ends we may, by using these ends of a different colour from the ground ends, show a distinctly coloured stripe. The closeness of the warp threads will so completely hide the weft that the colour of the warp only will be seen ; consequently, the weft and the gauze warp may be of the same colour, and so show a difference between ground and stripe. We may also form checks on the same principle ; let the stripe in the warp be formed exactly as above described, and to form the cross stripe use thick weft, and instead of weaving gauze into the ground let it weave plain, so that the gauze warp will be hid in the thick weft in the same manner as the gauze weft is hid in the thick warp. This mode of working has also another advantage apart from the question of colour ; the contrast between the compactness of the stripe and the openness of the ground makes the pattern most striking.

In some cloths more substantiality is required. Instead of forming plain stripes upon gauze ground, gauze stripes upon plain ground are formed, and with very pretty effect. We give one illustration upon Plate 10, where we have a drab ground and a pure white stripe ; of course we use white weft only throughout, and white warp in the gauze stripe, the ground warp being drab,



PLATE X.

and so closely set as to completely cover the white weft.

Perhaps a more effective method of forming stripes upon gauze is to work the stripe as a satin. We can then give any degree of fineness to it, and present a perfectly smooth surface. Some of the most beautiful examples of striped gauze have the stripe worked in satin. This class of stripe also gives some pretty effects when a little figuring is introduced into the gauze ground, and nothing is lost if the figure be run over ground and stripe indiscriminately, and more especially if the figure be formed with weft satin. In such case it becomes necessary to put a number of picks together in the gauze, and also sometimes a number of ends also, so as to give sufficient fineness to the figure, and make it cover well enough.

96. Combination of Gauze Figures and Figuring with extra Warp.—From what we have said, it will be clear that a great variety of effects may be obtained by combining various orders of weaving with gauze, and using only the material which takes part in the formation of the ground fabric; but, as in other classes of cloths, this variety may be very much increased by the introduction of extra material, warp or weft. It must, however, be borne in mind that we have not the same freedom for the use of extra material upon gauze cloths that we have upon simple plain or figured fabrics.

In these cloths we may use extra warp or weft, or both, forming figure on the face, and then passing to the back, and being bound to the back of the cloth, instead of being cut away. We cannot do the same upon gauze—the open texture of the cloth would show it; we must either use only what will form the figure, or we must cut the waste away from the back. Again, for reasons we have pointed out in reference to ordinary warp or weft figures, we cannot very well figure upon the gauze itself, but must form a plain ground upon which to do so, in order that when we

introduce extra materials to form figures, we must also figure to some extent with the ground material also. In speaking of figuring with extra material, at present we are speaking of it as an extra colour; in fact, as a means of giving more variety of colour to the pattern, but we shall shortly have to speak of the use of extra material for a different class of figuring; however, in the meantime we must confine ourselves to the use of it as an additional colour. Figures made with extra warp, whether upon gauze or other grounds, must either be arranged stripewise, or the whole surface of the cloth must be figured. It does not necessarily follow that in all fabrics the figures appear to the eye as being in stripe form, even though they are so arranged, whether the loose material be cut away from the back or not; but in gauze cloth unless the material be cut away from the back they *must* appear in stripe form. The figure, as we have shown, must be formed upon plain ground. If when it is completed we change the structure from plain to gauze, and leave the material on the back, it will be clearly visible through the gauze, and being visible as so much loose material it would not add to the appearance of the fabric; then it must be cut away. Before being removed the same rule must be observed as in figuring upon ordinary fabrics, of binding it round the edges of the figure, so as to prevent it slipping out. Then if we wish to avoid the cutting off at the back, we must make the plain continuous throughout. Although this is a disadvantage, as to some extent crippling us in our power of producing patterns, yet we may obtain some very pretty effects in stripes; one simple example is shown in Plate 10. In this we give coloured and white stripes alternately, but we may have other colours at will, and not only each stripe of a different colour, but several colours in each stripe. One ready means of introducing more colour, without adding much to the weight, is to let the extra warp take the place of the ground warp in forming plain cloth under the figure. For instance, if

we wish to have two colours in the stripe, whilst one of them is forming pattern on the face, the other is forming plain cloth under it, and they are constantly changing places according to the pattern, each forming figure and plain alternately.

97. Figuring with extra Weft upon Gauze.—

Figuring with extra weft upon gauze frees us from the necessity of making the figures in stripe form. If the weft be thrown all across the piece, we shall, of course, form stripes in that direction, but we may use the swivel shuttle, and so place our spots as we please, exactly as if we were figuring upon a compact cloth as shown in Plate 4, instead of upon a perforated fabric; the same rule will, however, apply to these as to extra warp figures, of the cloth being plain under the figure. Indeed, no matter how we figure upon gauze, we must have plain cloth somewhere about the figure. We have no other means of distributing the warp and weft threads, or of securing the proper form of the design. When we are using extra weft, we have all the advantages and opportunities of ornamentation which can possibly be obtained, for we may not only combine figures with gauze, but we may combine all the forms of figuring—plain figure upon gauze ground, gauze figures upon plain ground, loose weft or warp figure, figures formed after the character of damask, or with extra material in any colour or any number of colours. We may make extremely light fabrics, or we may give to heavy fabrics the appearance of lightness by the introduction of gauze figuring. Sometimes very pretty effects are produced by figuring with extra weft of the same colour as the ground, but in different material, or in thicker yarn of the same material, so giving prominence to it merely by the thickness of the yarn.

98. Combination of Gauze and Plush.—We have not yet, however, quite exhausted the means of ornamentation of gauze cloths. In addition to the methods we have already described, we may introduce pile or

plush figures. There are two distinct methods of doing this: first, when the pile is formed upon gauze, and second, when the pile is formed upon plain surrounded by gauze. Now as to the figures formed by pile upon gauze ground, we have the means of obtaining pretty and novel effects. The ends of warp which are to form the pile assist also in forming the gauze. Plate 9, Fig. 14, shows a longitudinal section, indicating the manner in which the threads twist round each other, and how the loop of the pile is formed. In this it will be seen that one of the three threads is constantly twisting round the other two, and at intervals one of these issues from the cloth and forms a loop. The manner in which the loop is made will be fully explained in the next chapter; we merely wish to call attention here to the fact of its being formed. On each side of the loop formation a weft thread is inserted, represented by the dot, and the crossing thread passes from one side to the other of both the loop thread and its companion. This constant twisting taking place, the loop thread is held firmly between the straight thread accompanying it and the crossing thread, so that whatever loop is formed it is held rigidly just as it is made. Sometimes it is cut, so forming velvet pile; and even though there is really no solid cloth under it, it will be so firmly bound between the ground threads that there will be no fear of its slipping out or being easily pulled out.

In the second class, as it may be termed, of plush figures on gauze, instead of the pile being formed actually upon the gauze, plain cloth is formed by a portion of the threads and the pile by the other portion, as shown in the section, Plate 9, Fig. 15. By this system, all the threads share in the formation of the gauze, as in the other, but when we come to the figuring they are separated into two portions—one for the ground cloth and the other for the pile—so that a solid cloth is formed in the ground. The pile is not held so firmly as

in the previous case, but still sufficiently so to make a serviceable article, and it has the advantage of making a more solid structure. There is necessarily more warp employed, more threads running together in the gauze, and consequently a heavier cloth. The principle of the formation of the pile is the same in every respect, but it issues from the plain cloth instead of from the gauze cloth. The pile may be cut or uncut, exactly as in the previous case.

Beautiful effects are produced by this combination of gauze and pile weaving; but of course the pile is of the same colour as the ground, when the figuring is distributed over the whole surface. Sometimes, however, the plush is made to form stripes; then different colours may be introduced, or, indeed, we may have coloured figures all over. But as the pile threads have to take part in the formation of the gauze ground, if we have two colours of warp the ground will necessarily partake somewhat of the colour of the figure, though modified by the presence of the second colour; but where the figure runs in stripe form it may be totally different from the ground. To give variety to figured goods of this description, we may combine with the pile or plush figuring any or all of the other modes of figuring we have referred to. If the figure run in stripe form, we may combine with it figures formed by extra warp, or plain, satin, or other figures in the ground. If they are distributed all over the surface, we may introduce extra weft and any other forms of ornamentation, and so make our patterns as elaborate as we please; and again, instead of the gauze being an ordinary plain one, with any number of threads running together, we may use any of the fancy gauzes—such as are shown in Plate 9—so that by the contrasts of colour, or such as are produced by the variety of structure in the fabric, we may ornament to an unlimited degree, and in all cases produce pleasing effects.

99. Lappet and Whip—net Figures on Gauze. We

have now but two forms of ornamenting gauze cloths to refer to, both of which have to some extent been anticipated—first by lappet threads, and second by threads crossing over wide open spaces. We give an illustration of lappet figuring in Plate 9, Fig. 16, and of the crossing threads over open spaces in Fig. 17. In the first we have an ordinary plain gauze ground, with single threads forming figures by being stitched as it were over the surface; this stitching is done in the manner described at Art. 85. By this mode of figuring considerable variety may be produced, but all by a series of single threads. An appearance of solidity might be given to the figure by crossing and recrossing in quick succession, say at every pick, but generally such effects as shown here are more aimed at. This mode of figuring is seldom combined with others, being usually applied to fabrics of very light texture. The same remark will apply to the class of figuring shown in Fig. 17, but the designs are of a stiffer character. This arises from the fact that each thread is arranged to be brought into the cloth only at two certain points in relation to the warp threads, though their positions in relation to the weft may be varied—that is, the number of picks inserted between each point of interweaving may be varied, but the number of ends cannot, in the same piece of cloth; therefore the figures must partake of a stiff character, this stiffness only being modified by a varied arrangement of the order in which the ends are drawn through the doup, and consequently the manner in which they are manipulated. However, both lappet and this form of figuring will partake more or less of the stripe character, though the stripe may be almost hid by the variety of lines introduced.

100. The Materials from which to make Gauze.—One necessary part of the design of gauze fabrics is a proper consideration of the structure of the threads from which the cloth is made. From the nature of the

cloth, its open perforations, and the necessity for the pattern being very clear, threads of a smooth even structure, with little or no loose fibre on their surface, are best adapted. Silk being a long continuous smooth filament is best suited of any class of yarns. Next come cotton and linen, for although they may have a little loose fibre on the surface of the thread, yet it will be very little, and not likely to interfere much with the clearness of the pattern. We may also use worsted yarns, but they will not give the same clearness of pattern as the other three, especially if not made from the finest wools. Woollen yarns are quite unsuited for making gauze cloths, as are also the coarser cottons and tow yarns; though, if well twisted, they may be employed in making the heavier goods when gauze is combined with twill or other forms of working, and where clearly defined patterns are not needed. It is not only so as to obtain clearness of pattern that smooth even yarns are required in making gauze, but it is necessary to have a strong thread in the warp at any rate. When the crossing takes place considerable strain is thrown upon the threads, and also great friction; probably the latter is most likely to do harm. If the thread is not strong and well twisted, it will soon give way under the friction, and if it has much loose fibre on its surface, there will be a great amount of friction in the threads passing each other, and also in passing and repassing through the eye of the heald, so that the smooth thread is as necessary to the successful operation of weaving as to the clearness and definition of the pattern. In fine woollen yarns with the thread sufficiently twisted as to give strength to the yarn to bear the work it has to do in the process of weaving, some excellent effects are produced by the combination of gauze with other orders of working, chiefly with twill in stripe form, but the texture must be very open, the threads being set a sufficient distance apart to reduce friction to the lowest point, so

as to obtain all the ease possible in weaving, and even then the pattern of gauze will not be well defined, but will be partly hid by the loose fibre on the thread. Perhaps it is this want of definition which gives the charm to this class of fabric; the perforations are not clearly marked, there is a kind of hazy mystery about the pattern which probably renders it more attractive than if it were well made out, and what adds to the attractiveness is that the character of the gauze is quite in keeping with the body of the cloth. At any rate, some really charming fabrics are made in this manner, but they require great skill in the use of the material, because of its soft fibrous character and the amount of friction thrown upon it in the process of weaving.

101. Madras Muslin.—It may be necessary to refer to and point out the chief characteristics of some fabrics which bear a strong resemblance to gauze. In the first place, there are several varieties of extremely light texture, which at first sight, from their very lightness, would lead one to suppose they were gauze, but which are not necessarily of that material. The term gauze is often applied indiscriminately to all cloths of a light open texture, without regard to the mode of interweaving of warp and weft; but this habit is very misleading to the technical student. One class of fabrics, which gives pretty effects upon a light cloth, is known as Madras muslin. This is a very light texture indeed, with a figure formed by the introduction of a thick thread of weft into the ground and then cut away where no figure is formed, so that it is really an alternation of thick, or moderately thick, and very thin, light cloth. Similar effects are also produced in fancy coloured goods, two or even three colours of weft being employed to form figures, sometimes one weaving plain into the ground cloth, and the other figuring upon it, and sometimes both entering partly into the ground cloth, and figuring alternately; and, as in the previous case, when no figure is being

formed the extra material, which would otherwise go to the back, is cut away. In the arrangement of patterns for such fabrics we should be guided by the same rules as for figures upon ordinary fabrics; the only difference being that the ground cloth is of a much lighter texture, and the figuring weft in a great measure goes in when the figure is formed, as an ordinary ground pick, or partly as a ground and partly as a figuring pick. There must be proper care as to the distribution of figures, and all the other precautions which usually accompany the arrangement of them. We must not omit net and lace in our comparison of fabrics, often confounded with gauze.

102. Net.—Whip net, a class of fabric formerly made, but now almost entirely superseded by lace, was really an extension of gauze weaving of a very complicated character. The pattern given in Plate 9, Fig. 17, may, perhaps, be called a species of whip net, though of the simplest kind. What is termed the whip or crossing thread, is made to pass over a greater distance than in ordinary gauze weaving, and frequently they not only cross what might be termed straight threads, but also cross each other, the crossing of the weft threads between them at the point or points of intersection keeping them in their places. Sometimes these weft threads would be so thin as to be scarcely visible to the naked eye without careful examination; and the whip threads being thick, all the appearance of lace would be obtained by the variety of crossing and interweaving. Although whip net produced some beautiful fabrics, it has been superseded by bobbin net and lace, partly because of the superior figured effects which can be secured, but mostly on the ground of economy.

Bobbin net, as its name implies, is formed by having a series of bobbins, which are made to travel to and fro in a pair of "combs," or bars. A series of threads are placed vertically, and the bobbins, which are extremely

thin, are passed through between them from one comb to the other; they are then returned, *but not through, between the same threads*. A lateral motion is given to the combs, or bars, termed "shogging," so as to move the threads to a different position in relation to the bobbins, thus causing them to pass through between different threads at each movement. The effect of this is to cause the bobbin thread to twist round the straight, or what may be termed the warp thread; and as bobbin and thread are moved at each passage of the bobbin, the bobbin thread is passed round each warp thread in succession, as shown in Plate 9, Fig. 18. Sometimes small spots are formed upon net by one thread traversing a number of times across the "mesh," but these are not large or elaborate, and call for no special skill, except so far as applies to regulating the movements of the machine.

Net very nearly approaches lace in its structure, but in the latter more elaborate designs can be produced.

103. Lace.—It is not our intention to deal at length with designing lace for two reasons: firstly, lace is not strictly speaking a woven fabric, and secondly, because to do justice to the subject it would require a complete work in itself. We shall, therefore, only refer to the general character of the structure of the fabric, and the manner in which patterns are formed, so that we may be able to compare with other fabrics.

If we examine the cheaper kinds of lace curtains, we shall see readily how the fabric and design are formed; and we can then understand more easily the formation of other kinds of lace. In the curtains referred to there is first a straight warp thread; along with this is another, which when no figure is being formed remains with the straight thread; these two have constantly a third thread twisting round them. When figure is to be formed, the figuring warp thread passes from one straight thread to the next, is made fast to it by the twisting thread, then returns to its former position as shown in Plate 9, Fig. 19.

This passing and repassing of the figuring thread is carried on with each one all over the fabric, according to the pattern to be produced.

This is, perhaps, the commonest kind of lace, but it will serve to convey an idea of how lace is made. In other kinds of lace those threads which we have spoken of as straight, and which in the common laces remain straight, are drawn out of their course by the varying strain put upon them. A similar kind of twisting action takes place with the bobbin thread, but the warp threads are varied in their thickness. They are made to traverse varying distances, and are bound to different ends by the twisting of the weft or bobbin threads; this, coupled with the varying tension, causes them to be drawn, and to make any pattern that may be desired.

It will be apparent that lace gives by far the greatest scope for producing ornamental open texture. The whole fabric is formed of such texture; the shape of the openings, the lines made by the thick or the twisted threads are capable of infinite variation, so that the texture may be as light, as open, and as varied as ever the designer may please.

In net we cannot have the same variety; the "mesh" will be of the same form throughout, most generally hexagonal, and any figuring will be limited, usually to small spots; while in gauze weaving we have something which may be said to come in between the two, and is capable of producing effects which cannot be obtained in either net or lace, whilst, of course it cannot give the effects which lace can. In gauze cloths, as we have shown, we may vary the weight and texture in any degree, and at the same time ornament by the texture. We may combine gauze weaving with any or all of the other forms of weaving, and form such patterns as we like. In fact, the combination of gauze with other textures affords more scope for the production of ornamental fabrics than any other class of fabric or

texture. In lace there is not this power of combination, and we are therefore limited to the production of light, open textures.

CHAPTER VIII.

PILE OR PLUSH FABRICS.

104. **The Classification of Pile Fabrics.**—We have now but one kind of fabric to deal with, so far as the ornamentation in the structure is concerned, and that is the class known as plush or pile fabrics. This class differs in appearance from all others, having on its surface a series of short threads which issue from the cloth, and present the ends of the fibre to the eye, or the threads issuing from the cloth in the same way form a series of loops. We will examine each section in detail, so as to see to what extent the principle of ornamentation can be carried in it, and also its combination with other orders of weaving.

It may be said sometimes that pile fabrics are divisible into two classes, cut and uncut, or cut and loop pile, but that is not a sufficient division. They are separable into two kinds more distinct than cut and uncut—namely, weft and warp pile; that is, when the pile is formed by weft, or when it is formed by warp.

105. **Weft Pile.**—Let us deal first with weft pile, and examine it in all its forms. It consists in the first instance of a series of weft threads bound into the ground cloth at intervals, and floating over the surface loosely after the manner of a figure. This loose material is then cut by using a long bar of steel made into a knife at the end. This knife is extremely sharp, and is provided with a guide, which is simply a narrow piece of thin sheet-iron doubled so as to form a groove which fits on the knife. As it leaves the point of

the knife, the iron is welded into one piece, and is tapered off to a point, more or less sharp according to the length of the plush to be cut. This point is inserted under the weft floats, and as the knife is pushed forward it raises the weft up to the knife, which severs it, so forming the cut pile on the surface of the cloth. Take, for example, the section of a velveteen in Fig. 87, where two picks of weft are shown, one of ground and

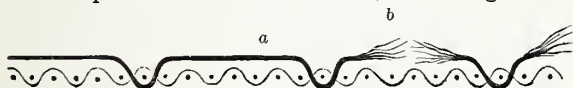


Fig. 87.

one of pile. The ground weft forms with the warp quite a plain fabric, while the pile weft passes under one end only and over seven. By inserting the point of the guide of the cutting knife under this pile thread and pushing it forward the tapering form of the guide will raise it up until the guide just holds it tight, when the knife coming in contact with it severs it, as shown at *b*, *a* being an uncut loop, just as it comes from the loom. Thus the pile is formed.

106. The Structure of the Cloth, and Binding Weft Pile.—We must consider the structure of the cloth most carefully in order to determine the best mode of binding the pile into the cloth, so as to make it serve the most useful purposes, and also the best distribution of the pile over the surface of the fabric. The ornamentation of the fabric may be left for after consideration, or we may deal with it as we refer to the different modes of structure, as well as the uses to which pile-surfaced fabrics may be applied.

The binding of weft pluses into the fabric to secure firmness is one of the most important questions in connection with their manufacture; for if it is not firmly bound it will not, in the first place, permit of its being cut—the knife will pull it away from the cloth; and in the second place, even if it were cut, it would constantly

be coming out in wearing. There would be no power to resist friction, and these are matters which must not be neglected. The firmness of the binding is in some degree dependent upon the compactness of the fabric, the firmness with which the threads forming the ground texture are bound and beat together, and perhaps more especially the closeness of the weft threads, so that the pile weft which is introduced between them shall be gripped, as it were, in a vice. It is also in a measure dependent upon the manner in which the pile weft is interwoven into the ground.

Very frequently the pile weft passes round only one end of the warp, as shown in Fig. 87. Then it may be said of such that it can make no difference how this binding point is distributed, because it will have to depend entirely upon the pressure of the ground picks on each side of it to secure it firmly in the fabric. The fact, however, that numbers of patents have been taken out for different modes of binding so as to make the pile more firm, and even when only passing under one end, proves that there must be something more than the mere pressure of the weft threads, or that this pressure may be increased by the mere arrangement or distribution of the pile. Let us take the case of a pattern of velveteen we have now before us, examine the manner in which it is made, and how it might be made, and see what the effect would be in each case. Fig. 88 is the plan of the cloth.



Fig. 88.

It will be seen that there are four picks of pile weft, each floating over seven ends and binding under one only. Then there is a plain pick, the four pile picks are repeated, and there is another plain pick. Those two plain picks will form a perfectly plain ground. Now, with regard to the pile picks, an examination of them will show that the four taken together would be equal to one plain pick—that is, every alternate end is occupied by them, and the *same four ends* are passed under by

the plain pick immediately following. Then the four pile picks are exactly repeated, and the next ground pick passes under the ends which have been passed over, and over those which have been passed under. Thus the first four plush picks would constitute as it were one complete plain pick, the ground pick a second, and the next four plush picks a third; so that we have an exact equivalent to three picks of weft in one shed, or under and over the same ends, and one in the contrary shed, or under those which have been passed over before, and over those which have been passed under. Now those three picks coming together as one, or, more correctly speaking, the nine picks coming together as three in one, will form one very solid mass when pressed together by the crossing of the warp for the next pick, and the driving of the latter up to the cloth, and each will help to bind the other into the fabric. The nine also becoming one, will allow a considerable number of picks per inch to be put into the cloth, so that we shall have weight, closeness of the pile, a solid compact cloth at the back, and the pile bound firmly into it. But there are other ways of looking at the subject. We may obtain too much weight of cloth if we beat the pick up close enough to make the pile firm. We have been speaking as if we were beating the weft as close as possible in the process of weaving, but if the cloth we have produced is too heavy, and we simply reduce the number of picks per inch, and retain the same arrangement of binding, we shall loosen the pile just in proportion as we reduce the picks:

That will not answer our purpose. However much we reduce the weight we must keep the pile firmly bound. Then suppose we adopt the arrangement shown in Fig. 89; this would have the effect of making each set of four plush picks and the ground pick following it go together as one, so that instead of being practically three picks together as one, and then a single one as in the previous case, they would be

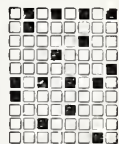


Fig. 89.

double picks throughout. This would possess two advantages: first, the plush would be even more firmly bound, because each set of plush picks is followed by a plain pick passing over the ends they have passed under, and two picks going together as one would make the whole order of interweaving firmer for the same weight, or equally firm for less weight; and secondly, the pile would be binding with *all* the warp, instead of only with every alternate end, as in the previous case, so giving more even distribution of tension upon the ends than before, and consequently a better constructed fabric.

Suppose, again, that the plush picks are arranged in their order of binding, that one portion of them goes into the same shed as the ground pick which precedes them, and the other portion into the same shed as that which follows them, they would require to be arranged so that equal quantities went into each. And even then they could not be held with the same degree of firmness as if they all went into one shed, because the pressure upon them by the ground picks would not be so evenly distributed, there would be a slight degree of waviness given to the ground weft picks which would make them hold one portion of the plush more firmly than another.

Binding the plush with one end of warp is sufficient only when the weft is so closely beaten into the cloth as to exert great pressure upon the pile, and hold it by pressure only; and in a large number of instances there is not enough of this pressure; in fact, it may be said that in the majority of plushes there is not. Then when such is the case we must resort to other means or methods of binding; we must let the plush weft interweave with more of the warp threads. We have a plan in Fig. 90 of

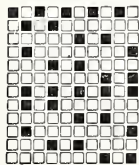


Fig. 90.

a velveteen similar in its arrangement to that shown in Fig. 88, but having the plush pick interweaving

with three warp ends, instead of one only. There are five plush picks to each ground pick; the pattern occupies ten ends instead of eight, but as the plush weft interweaves with three ends instead of one, the length of pile is just the same, floating over seven. The first five plush picks go under the same ends as the second ground pick, so do the second five, so that five complete picks go under every alternate end, and only one—the first ground pick—over them; thus it is equivalent to having five picks together in one shed, and only one in the other. Now this plan will possess all the advantages pointed out in reference to Fig. 88, with the additional one of the plush being even more firmly bound by interweaving with more warp ends. The back of the cloth will present less of the appearance of a plain fabric than even will that of Fig. 88, but it will form decided ribs, and there will be more strain thrown upon that half of the warp under which each plush pick passes. Certainly this strain will be somewhat neutralised by the thread having to pass *over* one only, but it will still be greater than the other portion of the warp. If we arrange the plan as shown in Fig. 91 we shall neutralise this, and give more plainness to the back cloth, and more firmness to the binding. There is, perhaps, one advantage, or so-called advantage, in the arrangements shown in Figs. 88 and 90 over those shown in Figs. 89 and 91—namely, in imitating warp pile. In the latter the pile runs distinctly in rows across the piece, because of its being formed with wires, as we shall show; and the arrangement of Figs. 88 and 90 will give more of the same appearance than Figs. 89 and 91. In each of the examples we have given there are four plush picks to one ground pick, and these four are distributed over the whole surface; but it must not be taken either that there are always four plush picks to one ground pick, or that

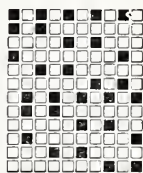


Fig. 91.

the plush picks between each pair of ground picks are distributed over the whole surface; the number of plush picks will be regulated to some extent by the density of the pile required, and the distribution which takes place between each pair of ground picks will be dependent partly upon the number of plush picks to one ground pick and partly upon the length of the pile. For instance, if we were only having two plush picks to one ground pick in such a pattern as shown in Fig. 88, we should only occupy two ends out of the eight, while with the same proportion of picks in Fig. 90 we might occupy every alternate end, so that the order of binding will also interfere with it.

The patterns we have given in Figs. 79 to 82 are what are commonly known as "tabby" velvets, or velveteens; the term "tabby," as used in the trade, being synonymous with "plain." And in such patterns it appears to be a general practice to occupy only every alternate end, and in most cases also

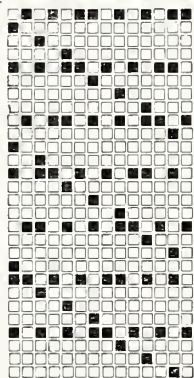


Fig. 92.

to preserve the arrangement shown in Figs. 88 and 90, of having one of the ground picks to go into the same shed as the plush on each side of it. There are some exceptions, and some of these are amongst the patented patterns. One feature of the perfect binding of plush into the ground, which has been made much of by practical designers of fabrics, is that the ground pick succeeding the plush picks shall be contrary to those plush picks in the order of interweaving at the point where they bind into the fabric. This is shown in Fig. 92,

where the ground is not quite plain, but nearly so, and the departure from plain is evidently due more to a regard for the proper binding of the plush than from any desire to produce a pattern on the

ground fabric. This is a most ingenious arrangement, and effectually secures the perfect binding of the plush into the cloth. The same principle of arrangement is applicable to plushes of any length, or with any number of picks of plush between the ground picks, or with the plush binding into any number of warp threads.

“Tabby” velveteens, or velvets, are only suitable for the production of light fabrics. The pile may be tolerably dense, but the ground cloth cannot be very heavy, because of the order of interweaving preventing the threads coming very close together; and as the pile cannot well occupy more than every alternate warp thread between the ground picks, the number of them issuing from the cloth in a given space cannot be so large as if there were more ground picks per inch. Then if we wish to increase the bulk or thickness of the cloth we must substitute twill or satin for the “tabby.” If we do that our binding of the plush cannot be so firm or perfect if it only passes under one end, but if interweaving with more than one end it may be equally perfect.



Fig. 93.

We have in Fig. 93 a plan of a velveteen with a three-end twill ground, and two picks of plush to each ground pick. In this it will be seen that again the principle of occupying every alternate warp end in binding the plush is employed, and also that every alternate plush pick falls in a different position in relation to the ground twill, and consequently that one half the plush will be more firmly bound than the other. Again, in Fig. 94 we have another pattern upon a three-end twill ground, but with three plush picks to one ground pick. In this, only one-third of the pile will be imperfectly bound. Now all



Fig. 94.

these are patterns which have been regularly used, yet they are not free from defects in their binding. They have probably depended more upon the mere quantity of the material which the fabric con-

tained for the firm binding of the plush than upon anything else, but this is not satisfactory; each pick should be equally perfect in its binding to ensure a good cloth, but with a twill ground, and more than one plush pick to one ground pick, this is difficult to attain when the plush passes under one end only, but if the plush interweaves with more than one end, then it can be bound perfectly. We showed in Fig. 91 the method of binding into more than one end upon plain ground, and also the best mode of making the pile firm. Precisely the same rule will apply to twill grounds, only that instead of interweaving with three ends it would be



Fig. 95.

probably with four, or even perhaps more, after the manner shown in Fig. 95.

In this section it will be seen that the pile issues from the cloth between two ends, which are passed over by the succeeding pick, and which are in consequence pressed close together at that point, and so tend to cause the pile not only to be firmly bound, but also to stand more erect on the surface after it is cut. In most pile fabrics the systems of binding shown would be quite sufficient to hold the pile quite firmly in the fabric; but sometimes the nature of the material, such, for instance, as mohair, renders it desirable to bind it more firmly into the cloth. Then, if the ground be plain, the pile may bind into as many ends as is desired, and a number of picks going to form one, always being arranged so that the point where the first pick, say, issues from the cloth, the next pick enters it so that the pick formed by the succession of plush picks shall be one complete plain pick, just as the five picks in Fig. 90 form two complete picks.

107. Distribution of Pile.—We now come to the question of the distribution of the pile, and here there are two distinct features to consider—first, equal distribution, so that the whole surface of the fabric shall be equally covered; and second, the arrangement, so that

what are termed courses for the knife shall be regular. Although, as we say, these are two distinct features, and both often exercise the mind of the designer, yet if the first condition be properly complied with, the second must be. Let us see what this distribution means. In the patterns Figs. 88 and 89 the four plush picks are arranged in what is commonly known as four-end satin, or satinette order. Each alternate end is occupied by a plush pick, but not in consecutive order. In this particular case they might have been arranged in consecutive order, as what may be termed the pattern is complete between each ground pick, but if there had been only two plush picks and one ground pick, then there would have been a tendency to show a twill, and this would not only have been apparent at the back of the cloth, but also on the face of the plush. Again, in Fig. 90, the plush is arranged in almost what may be termed a twill order, though not following on consecutive ends, yet from the manner in which they issue from the cloth, and the "pattern" again being complete between the ground pick, no twill will be visible. Generally, the best arrangement of plushes is that of a satin order, the number of changes being regulated by the length of the plush, and the number of plush picks required to complete "one round of the pattern." If we keep our plush distributed equally in this manner, we at the same time also insure regular courses for the cutting knife; the pattern being in regular order, the distribution perfect, we are of necessity bound to have perfectly straight courses. But if this regularity is not preserved, if the binding is distributed irregularly over the fabric, then the courses will be irregular, and the cuts will be "heavy and light"—that is, in one course there will be more material to cut through than in another, and so irregularity in the quantity of pile on the surface and difficulty of cutting properly will be produced.

108. **The Effects of Cutting Plush.**—Cutting the plush has quite as much to do with the ultimate appear-

ance as the regularity and perfection of the binding, though in the short plushes of which we have been speaking not so much difference can be made, perhaps, as in longer plushes. We have already explained how the plush is cut by the knife and guide. Now, this guide plays a most important part ; its first function is to raise the thread up to the knife, but it must also determine exactly where the knife shall cut that thread, in the middle of the float or elsewhere. This is governed by the size of the guide itself ; if the pile is all to be of equal length—that is, the float of weft to be cut exactly in

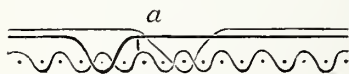


Fig. 96

the centre—then the guide must be just of such size that it will fill the space between the weft and the cloth

of *one float only*. Take, for instance, Fig. 96, where two weft floats are shown binding at two different places, as would be the case of any two picks in a plush pattern. If the knife-guide is of the proper size, it will pass under only one of these at once, but if it be not large enough, it will pass under two or more, as at the point *a*. In that case, instead of the thread being severed into two equal parts, one will be much longer than the other. Instead of being cut between the two binding points of one thread, it will be cut between a binding point of each thread, and so produce long and short plush intermixed.

109. Imitating Skins of Animals with Plush.—In such fabrics as velveteen, and others where the pile is very short, this would be a fatal objection ; the surface of the pile would present a most irregular appearance, but where the pile is of considerable length it may be an advantage. Very frequently plushes, more especially weft plushes, are made to imitate the skins of animals. Most people are aware that a great many animals have next the skin a short close fur, covered with a longer hair, the hair lying over the fur and serving to turn off the wet, while the fur serves to keep

the animal warm. In imitating such furs two lengths of plush must be formed. Sometimes this may be got sufficiently well merely by the cutting, using a guide so small as to catch two or even more picks, after the manner shown in Fig. 96, and so producing long and short. If three picks at different points of the pattern are caught by the guide, there will of course be three different lengths of plush, and so on. Sometimes, however, this does not give sufficient difference in the length of the plush, and the floats of the weft are varied—in fact, two distinct plushes are combined upon one ground; say, for example, one having a float of an inch in length, or even more, to form the long hair, and the other having a float of only a quarter of an inch. In cutting these, one of two courses must be adopted: either the long plush must be cut first, with a guide which cannot enter the short plush, or both must be cut together with the short plush guide. In the first case the long hairs may be equal in length, or unequal, according to the size of the guide used; in the second case the long plush will be all equal, and very nearly of the full length of the float, from one binding place to another, because the guide for the short plush will be so thin, and the cuts so frequent, that the long floats will always be cut nearly close to the binding point, the short end of it being just of the same length as the short or under plush. If two different materials be used, as fine wool for the short, and silk or bright mohair for the long plush, some pretty effects may be obtained, and very correct imitations of the skins of some animals made. Sometimes even three materials, each forming a different length of plush, may be employed, and more variety given to the fabric. In making imitations of skins, the nature of the material employed to form the pile must of necessity be properly considered; for instance, in making imitation sealskin, smoothness and brightness of the fibre are essential conditions. Again, if the pile is required to stand erect upon the surface of the cloth, unless it is very short pile, the hair or fibre of which it

is made must be very strong, so that it can retain its erect position.

110. Density of Pile.—Another question now arises—namely, the density of the pile. If it must stand erect it must be tolerably dense; that is, there must be a great many pile threads issuing from the cloth in a given space, so that they can support each other. To obtain this density of pile the number of plush picks to one ground pick must be properly proportioned to the length of the pile and to the number of ground picks per inch. It may to some extent be obtained by the use of thick pile weft, but this must not be carried too far, else it will appear rough and coarse. In obtaining density by an increased number of plush to one ground pick, we must not carry the proportion too far. Fig. 90 will represent what should be the limit; in fact, it goes almost too far. The ground picks must be sufficient to form a fabric of such weight and strength as will carry easily the pile to be put upon it. Perhaps the pile weft may take part in the actual formation of the ground fabric. Sometimes it does; then, of course, more strength is given to the structure. These are all matters in which the designer can only be guided by the circumstances of the case immediately before him. Empirical rules cannot be laid down, and if an attempt were made to lay such rules down they would only be misleading.

111. Special Effects produced by Yarns.—The same remark will apply also to the preparation of yarns for forming pile to produce special effects. For instance, in the imitation lambskin the yarns must be made from soft fine wool, with good felting properties; the softer it is spun into the thread—so that it will hold together to be cut—the better. Then after it is cut it must undergo a teasing process to separate the fibres as effectually as possible; then they are felted until they form little “cots” all over the surface of the cloth. Again, in the imitation of dog and other skins, the yarns must undergo a preparation which will give them the proper amount of

wave or curliness; and in some cases the subsequent processes of finishing assist or intensify these effects; however, all such must be left to the ingenuity and skill of the designer, and a due consideration of the effect he desires to produce.

112. Corduroys.—Plushes, in addition to being distributed equally over the surface, are often made to produce patterns upon the ground cloth, such, for instance, as stripes, which when they occupy a small space are commonly called cords, or, when they run the length of the piece, corduroys. They may also run across the piece, or in diagonal form. Figures are also formed.

In the small cords or corduroys the principle of binding referred to in velveteens is usually employed, only that the binding of the plush is not distributed over the whole surface, but confined to a few ends. We have in Fig. 97 a simple cord on a plain ground cloth, which is known as a "velveret on tabby back." In this the binding of the plush weft is confined to two ends throughout, so that when cut up between the bindings the pile will form a rib or cord. In Fig. 98 we have



Fig. 97.



Fig. 98.

the same cord on a three-end twill back, otherwise known as the "Jeanette" back. In these two patterns there is nothing which calls for special remark, except the formation of the cord: it is one of the most simple which can be made. In Fig. 99 we have one on a four-end twill ground, which is a more perfect form of cord. These cords, to give the best effects, should be rounded on the top; that is, the pile forming the centre of the cord should be longer than that forming the sides, so that it will stand above it and give a rounded appearance. In the patterns given in Figs. 97 and 98 this will take place to a slight extent, but in pattern Fig. 99 it will be more

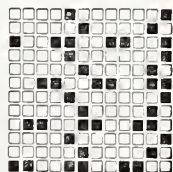


Fig. 99.

marked. Take the two plush picks which occur between each ground pick. The first pick has a float of four and then of six ends alternately; the second pick is the same, but the long float of one follows the short one of the other. The cutting will sever both threads in the centre of the float, so that the longest ends of pile will be in the middle of the cord, and the shortest ones at the sides or edges. This, then, will give a greater degree of roundness than in Figs. 97 and 98. Although the pattern in Fig. 99 will give a rounded cord, in many cases it is desirable to have even more roundness and prominence imparted to it; this may be done by giving three or four different lengths of float to the pile weft,



Fig. 100.

and generally arranging them so that the longest are slightly predominant in quantity; such, for instance, as that in Fig. 100, which would produce a very bold cord. In this pattern one of the two plush picks forms the edges of the cord only, while the other forms the intermediate and the centre, thus giving more threads issuing from the centre of the cord than the edges. This would make the cord very full up the centre, but as part of this would fall towards the edges instead of remaining perfectly erect, it will supply proper roundness to the cord. Cords of this description may be made of varying widths, and with any degree of roundness; and they may not only be made as plain straight cords, but as fancy ones, and of varying sizes.

113. Diagonal Cords.—It is not necessary that we confine ourselves to cords running either the length of the piece, or simply across it, parallel or at right angles to the edges, but they may run diagonally, and the weft which forms the pile rib may either be introduced to form the rib solely, or it may take part in the formation of the ground. After the consideration we

have given to straight cords it will not be necessary to say much about diagonal cords: the principle of structure and binding applies equally to both; the roundness of surface on the cord required in one may be equally desired in the other, and the mode of obtaining it would be the same. In fact, instead of binding all the plush picks upon a given number of ends, they would be distributed upon all the ends composing the fabric, and following each other in a diagonal direction.

114. Figured Plushes.—Figures may be formed with weft plush in the same manner as cords or diagonals, simply by binding the plush weft into the cloth where figure is to be formed, as though the whole surface were to be covered, and where there is to be no figure, either let the plush weft enter the ground as part of it, or float loosely over it. In the latter case, the loose material which is not forming pile will have to be cut away. Some very pretty effects may be produced in this manner, as also in the formation of figures by different lengths of pile, or by the use of different colours of pile weft. In fact, we have in this system of ornamentation the means of producing great variety of effect, as well as most useful fabrics, not only for wearing but as warm articles of clothing.

115. Chenille.—Chenille is another class of fabric, if we may so term it, which though used for a great variety of purposes, may be classed among weft plushes. The mode of its manufacture is by weaving weft into a warp having its threads set in small groups a short distance apart. After the piece of cloth is woven, the whole of the weft is severed between each group of warp threads, thus cutting the whole fabric up into

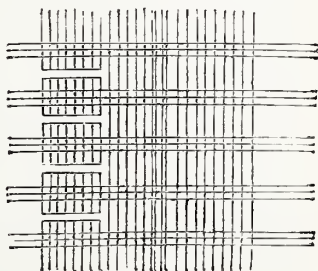


Fig. 101.

narrow shreds, as in Fig. 101. Here the warp threads are shown in groups of three, and are intersected by the weft in regular order; sometimes these warp threads weave with the weft in perfectly plain order, but in the best formed chenilles they are woven as gauze, thus holding the weft more firmly in the warp, making the cutting more easy and certain, and making a more durable article. After the chenille is cut it is twisted, all the three threads of warp being thus formed into one, with the short threads of weft projecting from it all round, making as it were a fringed thread. This twisting tends to hold the weft fringe still more firmly in the threads of warp, so that if in the plain woven fabric it can be held sufficiently firm to resist being pulled out in cutting, it will become more secure after the twisting operation.

116. Sham Plush.—One of the uses to which chenille is sometimes applied is the production of what may be termed sham plush; that is, it is woven into a cloth as weft, and the loose fringe formed on the thread, as before described, projects itself through between the warp threads, and so gives the fabric the appearance of a plush. If it is woven into a plain piece, there is, of course, the same quantity of plush on each side of the cloth, but if thrown pretty loosely on the face it will present very much the appearance of an ordinary plush, and can be made much more economically. One thing which is necessary in making cloths with chenille weft is to have the warp threads pretty wide apart, so as to give the loose fringe an opportunity of projecting itself between them; if put into a closely set fabric it would not have an opportunity of doing this, and would consequently be nearly, if not entirely, lost. Chenille, if judiciously used, gives some very pretty effects indeed, and at a cheap rate compared with what can be done with other kinds of plushes.

117. Warp Pile.—We now come to the question of the formation of pile or plush on the surface of

fabrics with warp. The principles involved in the formation of pile of this description are similar to those of weft pile, the warp taking the place of weft, but the *modus operandi* is different. In the formation of weft pile two wefts and one warp are employed; in warp pile, two warps and one weft. In the former the cutting takes place usually after the cloth comes from the loom, in the latter usually in the loom, or the pile may be left uncut and form loops; so that we have two forms of warp pile, commonly known as “cut” and “loop” pile, or “cut” and “Terry” velvet. Whether the pile be cut or uncut the structure of the cloth is the same; it is merely a question of using the knife or not. We will first examine what is known as common velvet—as there are several modes of forming the pile, or rather of binding it into the cloth—so that we may obtain a more ready and accurate idea of the general principles upon which the binding is effected.

118. The Structure of Velvet.—In the first place, velvet is formed by the pile warp issuing from the cloth, passing over a wire, and then passing into the cloth again, where it is interwoven, so as to secure it firmly. We may bring the whole of the pile warp at once over the wire, or we may bring only a portion of it, but in either



Fig. 102.

case we must consider the binding, so as to properly secure it; and in the event of bringing only a portion over the wire at once, we have the double consideration of binding and proper distribution. Suppose we first bring the whole of the pile warp over each wire, as shown in the section in Fig. 102, we bind the pile threads into the ground in the order of plain weaving between each wire. In this section the loops are shown

just as they are formed by the wire, except at *a*, where they are shown as cut. Now, one feature of this section must strike the reader : the pile issues from the cloth after a pick is inserted, passes over the wire, and returns to the cloth before another pick is inserted. To secure the pile properly in the cloth it must pass *under* the pick which precedes the wire, and also that which follows it, and the ground thread next to it must pass *over* both these picks, so that virtually both are in one shed. It must not be supposed from this section that the pile thread necessarily forms part of the ground, that is, that the thread seen here and the ground thread accompanying it are the only two representative threads of the cloth ; but a ground thread accompanies the pile thread in the order of interweaving in the ground, so forming a double thread throughout, except in passing over the wire, when they separate. Thus this arrangement secures the pile firmly into the fabric, and the double pick has also another advantage—namely, that the pile threads issuing from and returning into the cloth between two picks which are contained between the ground threads in the same shed, and which are beaten as closely together as the thickness of the pile warp will permit, are held firmly together, thus supporting each other and standing erect upon the surface of the cloth. This method of binding the plush gives all the security to the binding which is required, but it will form distinct rows or ribs across the piece. If the pile warp be thick enough, and spread itself out sufficiently on being cut, these rows will be hid, but if the cloth be doubled back, each row will at once disclose itself. This is certainly a characteristic of all velvets, and is the feature we referred to in Art. 106, which is imitated by the velveteen when two sets of plush picks and one ground pick pass into practically the same shed, thus giving a sort of ribbed effect to the back of the piece, and showing the plush in rows. If we are making our cloth with fine ground weft these rows would be so close together as not

to be at all objectionable; in fact, not visible to the unassisted eye. Again, in the process of weaving we must consider the effect of weaving in this manner. If the warp be a smooth thread and not over thick, as silk, for instance, we may raise or depress all the pile threads at once, without fear of "choking" the shed, but if the pile threads be very thick, or not of the smoothest nature, or too closely set, then there would be a probability of "choking" as they pass between the ground threads, and probably also the rows and the openings between them would be too decided. Then in such cases we must divide the pile warp into at least two portions, and bring each portion over the wire alternately. In doing so we alter the structure of the cloth. Practically, each portion of the pile warp is bound into the fabric, just as shown in Fig. 102, but as we have *two* portions to consider, *each* to be bound in a similar manner, the order of succession of ground picks in their relation to the ground warp must be altered. A section is given in Fig. 103, showing the method of binding the warp when bringing only half over the wire at once. The black line



Fig. 103.

represents one portion of the pile warp, and the dotted line the other portion, the ground end being represented by the double line. In this, as in the previous arrangement, the pile issues from and returns into the cloth between two ground picks which are in the same shed, being held so exactly in the same manner. Again, on returning into the cloth it passes under one pick, over two which are in the same shed, and under another, when it again issues from the cloth; so that practically each portion of the pile weaves into the ground in precisely the same way as in the previous case—namely, three ground picks and a wire, two of the picks being practically

one, so far as this portion of the pile is concerned. Then the other half of the pile warp issues from and returns to the cloth between the next pair of picks, thus making a loop at every two picks of the cloth, but two picks always going into the same ground shed, being separated by the pile warp as it issues from and returns to the cloth. Such being the nature of the structure when the pile warp is brought to the surface in halves, there must be a better distribution of the pile. The firmness of the binding and the texture of the ground cloth will be practically the same in both methods of working, but in the second the rows of pile will not be so decided, their greater frequency, and the fact of only one half the pile coming to the face at once, tending to equalise the distribution, and give a more regular appearance to the pile, more especially if thick yarn, or yarn made from strong fibres, be used.

What we have said has more especial reference to velvet, or cut pile. If it be uncut, forming loops, so far as the binding or the pile running in rows is concerned, there is no advantage in either system, because the pile will always stand in rows, just as it is left by the wire, but by bringing half the warp up at once we can get the rows closer together; and although each row of the pile brought over each wire cannot be quite so much in quantity as if all the warp be brought up at once, yet the increased closeness of the wires, and the fact that we can have the warp more closely set, will enable us to form a greater quantity of pile on the cloth.

119. Pile formed without Wires.—Loop pile may be formed without the use of wires, but its appearance is not so regular; although formed in rows, the loops do not stand perfectly straight, nor exactly equal in height; thus they intermix with each other, and give a very rough appearance to the fabric. This kind of pile is most used for bath towels and similar articles.

120. Ornamenting Pile Fabrics.—We must now turn our attention to the ornamentation of pile fabrics. This

we may deal with under two heads: first, the decoration *of* pile fabrics, and second, the decoration of fabrics *with* pile.

The first idea which naturally occurs in connection with the ornamentation of fabrics is the use of colour. In ordinary velvets, whether cut or uncut, colour can only be used under certain conditions, and consequently can only give some specific character of ornamentation, and not be used in a general way. The pile formed on the surface of the fabric entirely covers the ground cloth; then any ornamentation which may be visible must be formed with the pile warp. If we introduce variety of colours into that they must necessarily run in stripes; figures could not be formed. The warp consists of a number of threads laid side by side. If these threads are of different colours, a given number of one colour, and a given number of another, when woven into the fabric, and forming the pile on the surface, exactly the same stripe must be presented on the cloth as in the warp, so that our power of ornamentation in that direction is limited. Then our chief power of ornamentation must be by forming patterns in or with the pile itself, in a great measure without the aid of colour. When we speak of the ornamentation of pile fabrics, we naturally conclude that the whole surface of the cloth is covered with pile, or at least that the greater part is so covered, or that some ornamentation is formed in the pile itself, or by its being formed in varying quantities on the fabric.

First of all, we may produce pattern by the pile varying in length. When such is the case it will usually be in stripe form across the piece, because the difference in length is produced by wires of different sizes being inserted under the pile warp during the process of weaving, so that it would not be very convenient to form figures in this manner. Of course figures can be so formed, but the expedient is not very frequently resorted to.

The next means of ornamentation is by the combination of velvet and terry—that is, cut and uncut; and this

is very frequently employed, figures of terry being formed upon a velvet ground, and *vice versâ*. The same warp is employed in the formation of both kinds of pile, but two kinds of wires: one provided with a groove for guiding the "trevette," or cutting knife, or having a knife formed at its extremity so that it cuts its way as it is being drawn out, and the other being a plain wire which when drawn out leaves the loop intact. No prettier effects can be produced than by this combination of velvet and terry; although both are of the same material, and of the same colour, the contrast between the loop and the cut fibres marks the pattern very distinctly. One great advantage of this mode of ornamentation is that the texture of the ground cloth is not at all affected, the interweaving of the pile with the ground remains the same; the same amount of pile is formed all over the surface of the fabric, the cut and terry simply taking the place of each other, so that the usefulness of the article is not impaired, either in its strength or in the wearing surface, there being no inequalities whatever in the pile. In fact, this kind of figuring bears the same relation to pile fabrics that damask does to ordinary figured cloths. Figures may be formed upon velvet grounds by ceasing to form pile at intervals; for instance, taken in its simplest form, if we weave say half an inch of velvet in the ordinary manner, then cease to insert wires, but continue to let the pile warp interweave with the ground, we should form plain cloth, having two picks of weft in each shed, and with two ends going together as one. We are now assuming that the pile is formed by bringing half the warp at once over the wire; then we should have alternate stripes of velvet and plain cloth. But instead of forming simple stripes we may let our plain cloth form figures, and the figures may assume any form. Then we are ornamenting by the introduction of patches of plain cloth, such patches taking the form of figures, and being distributed according to the fancy of the designer, or the special effect intended to be produced. When figures

are formed in this manner, the plain portion of the fabric is a little more loose in texture than when pile is formed. As will be seen on referring to the sections of velvet in Figs. 102 and 103, when pile is formed, the warp separates the two ground picks, which otherwise go into the same shed, but if pile is not being formed, the pile warp simply lies under them along with the ground warp, so that there is nothing to separate the two picks, consequently they will lie closer together and occupy less space. Now, if one portion of the fabric has two picks together as one, and another portion has the same two picks separated by a series of double threads, one must of necessity be firmer in texture than the other. Perhaps this difference is not such as to have a material effect in the majority of fabrics, yet it is necessary to be aware of its existence, since if the pile warp be very thick, or the figures be not equally distributed, it may be detrimental to the structure, and a knowledge of the possible cause of defects enables us all the more effectually to guard against them.

In addition to irregularities in the texture, the wearing surface is also irregular, the velvet standing up as a projection on the surface of the fabric; but for the purposes to which such goods are usually applied this is not a matter of much importance. Plain figures of this description upon velvet grounds are about the most simple mode of ornamentation, though a very effective one, the design produced being of an embossed character. In fact, common velvets are frequently made to imitate them by being embossed, but these are not so good for wearing purposes as when they are properly figured, because that portion of the pile which has been flattened by pressure to form the figure will become loose with friction, and gradually rise to almost its former position and so destroy the pattern, whereas if the pattern be woven in, nothing can destroy the clear definition of the figure except the actual wearing away of all the pile of the ground—a circumstance which cannot often occur.

121. Combination of Pile and Figuring with extra Material.—Fabrics figured in this manner are like those figured with velvet and terry, necessarily all of one colour; but variety of colour may be obtained by the introduction of extra material, after the manner pointed out in reference to ordinary fabrics, and in this way some of the richest possible effects produced; the density of colour which is always a characteristic of velvet, and the variety of light and shade produced by the pile, being wonderfully relieved, and giving the most beautiful effects by the introduction of bright or contrasting colours. There is probably no class of ornamentation applied to fabrics which gives such magnificent results as combinations of velvet with coloured figures.

122. Pile or Velvet Figures.—We now come to the ornamentation of fabrics with plush or pile, and what has been said of the ornamentation of pile will practically apply to this, in so far as structure of the cloth and wearing properties are concerned; the mechanical operations required for the formation of patterns are also the same. In fact, we may almost sum up the difference by saying that in one case the plain or figured ground cloth becomes an ornament to the pile surface, the latter of which predominates largely in quantity; and, in the other case, the small quantity of pile which forms a figure becomes an ornament to the ground cloths. The fabric which we wish to ornament with velvet figures may be anything—plain, twilled, satin, figured, or gauze. It is made on the ordinary principles. The warp which is to form the pile may take part also in the formation of the ground; it may form figures in the ground, or may be dealt with in any manner when not forming velvet; then when it is required to form velvet it begins to interweave with the ground cloth in the ordinary manner of plain velvet, and is also passed over wires in the same manner. Sometimes the velvet is formed in stripes; when such is the case there is no trouble with the arrangement of the design, further than to provide the pile ends in the warp,

and consequently in the arrangement of the pattern upon paper, at the places and in such quantities as are requisite. The stripes may be plain or figured; when figured, the pattern is produced by simply passing such ends over the wire as will form the figure desired, and leaving the rest in the ground cloth. If the figures be distributed over the whole surface of the cloth, at greater or less intervals, then they must be distributed equally; in fact, the same rules must be observed as for any ordinary figures. Plush figures upon a ground fabric differ from plain figures upon a plush ground in one respect—namely, that the figure may be different in colour from the ground, more especially if the figures be small, because then the pile warp would be treated as extra material, and thrown to the back when not forming pile. Of course, in plain figures upon plush ground, a similar effect may be produced by the introduction of extra material, as we pointed out for the formation of extra spots; but this is not so general a practice as introducing extra warp to form plush figures. Then again we may combine extra material for the formation of other figures, after the manner of ordinary cloths between the plush or velvet figures, or we may figure with the ground fabric. In fact, we may combine with velvet figuring all other forms of ornamentation which can be applied to fabrics; and our velvet figures may be either cut, or terry, or both.

123. Plush Figures upon Gauze Ground.—We have already referred to the formation of plush upon gauze ground, but that will call for a few more words here. As it is shown in Plate 12, Fig. 14, the pile is formed *upon* the gauze; that is, the twistings of the gauze threads take place between the loops of the pile, so that really there is no solid ground fabric under the pile. This is a very pretty and useful mode of working, but will only serve for very light fabrics, and does not permit of any other mode of ornamentation being applied along with it. Now, we may frequently wish to combine plush figuring

with some other upon gauze ground, or plush figuring with gauze upon some other ground. Suppose, for example, that our plush is to be surrounded with plain upon a gauze ground; then in the first instance we combine plain with gauze in the usual manner, then, as plush is to be formed, we cease the plain working and adopt that which will give a proper ground for the plush, and proceed to the insertion of the wires. This mode of working, in addition to enabling us to make a heavier cloth than if the plush is upon the gauze direct, will also make the plush appear better by being more dense. Again, the plain cloth may predominate, and figures be formed alternately by plush and gauze, or we may further call the use of extra material to our aid; so that we may be said to have here all the different methods of ornamentation at our command at once, to apply as we please. There is, perhaps, nothing which produces such striking effects as the combination of plush and gauze, whether any other order of weaving be combined with them or not; the contrast between the density of one, and the open perforated character of the other, always giving a very decided character to the whole design, and, at the same time a very pleasing one.

To the designer there can scarcely be any more pleasing duty than the designing of figured velvets; he has so much scope for the display of artistic merit, and also of complete technical knowledge of the structure of fabrics.

124. The Production of Special Effects in Plushes.—

In dealing with warp pile so far, we have confined ourselves chiefly to velvet, or fabrics having a very short pile; but there are numerous other kinds of pile fabrics in which the pile varies, though in principle of structure they are practically the same. But although they are the same in structure, yet great variety of effects is produced by varying lengths of pile, by special preparation of the pile warp before being put in the loom—such as printing, curling, waving, &c.—similar to the

operations we referred to in connection with weft pile; and, again, special effects are often produced in the process of finishing after the fabric leaves the loom, such as tinting to produce the imitation of skins of animals, and other effects.

125. Brussels Carpets.—Figuring with colour upon pile fabrics involves a different arrangement of the structure and also of the pile threads, unless the pattern is printed. We might take as an illustration Brussels carpets, in which well defined patterns are formed by a variety of colour, and see what is the principle of structure, and how far it will apply to others. The pile itself is formed exactly the same as in ordinary or terry velvet—namely, by the insertion of wires under the pile threads—but the process of selection of the threads is different. In weaving ordinary velvet we bring either the whole or half the pile warp to the surface over each wire, but in Brussels carpet we may be said to have a

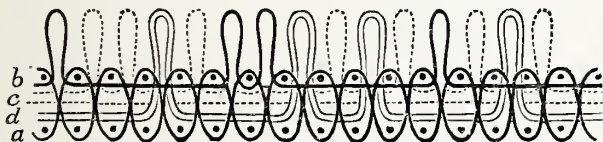


Fig. 104.

series of duplicate ends, each of a different colour, and from these we select one, according to the pattern we require. Again, in ordinary velvet the pile warp interweaves into the ground just the same as the ground warp, except at the point where pile is formed; but in Brussels carpet it does not, but is contained as a straight thread in the body of the cloth when not forming pile. Take the section Fig. 104; the ground warp is represented by the lines *a*, and the weft by the dots, the three colours of warp by *b*, *c*, and *d*. Now the ground cloth is plain in one sense. If the ground warp threads be separated from the pile warp, and considered only in relation to

the weft, they will form a plain cloth with two picks in each shed, but taken as they stand, the ground picks are separated by the pile warp. In fact, the pile warp is held between the ground weft, and intersected by the ground warp, so that if no pile or loops were to be formed, we should have a plain cloth with a stout packing in the middle, the packing threads being perfectly straight, and taking no part in the formation of the cloth, except to give bulk to it. Between every pair of ground warp threads there is one thread of each colour of pile warp which is to be employed. Then, for the formation of the pattern, *one* of each of these sets of pile threads is raised between each pair of ground picks and passed over a wire, it then returns to the cloth, and if required to form the next loop is again raised, and so on, until its own portion of the figure is completed, when it remains in the cloth until again wanted to form figure. In the same manner the pile threads are treated; they are lifted over the wire to form a loop whenever the arrangement of the pattern calls for their presence on the surface, and as soon as that portion of the pattern is completed they return to the cloth, and continue to form the body. From this it will be seen that although there may be three, four, five, or six colours, and consequently as many separate pile threads between each pair of ground threads, only one of each set is brought to the surface at once, so that there is always the same quantity of pile on the surface, and the same substance in the body of the cloth, no matter what the pattern may be, or how frequently the pattern changes from one colour to another.

Then the advantages of this mode of structure are that we have uniform surface and body of cloth; and we have pattern formed by colour only, and any amount of variety in the pattern will not affect the structure or quality of the cloth. The pattern being formed by differently coloured threads coming to the surface in succession, is very clear and well defined, and the whole of the pile material being embedded in the body of the cloth

makes the fabric both bulky and soft. One peculiar advantage, from the useful point of view, which Brussels carpets possess, is that each thread which comes to the surface to form a loop, being only one of a number, is well embedded with the rest in the body of the cloth, so that when the foot is placed upon it, it is pressed into a naturally elastic body of material, which serves as a cushion for it, enabling it to give way under the pressure of the foot, and also by its elasticity to spring back to the original position, thus reducing the wear and tear considerably.

126. Tapestry Carpets.—Another class of carpets which are made to imitate Brussels are known as tapestries. The structure of the cloth presents somewhat the appearance of Brussels, but instead of there being a number of threads together of different colours between each pair of ground threads there is only one, and that is printed so as to form the pattern. In fact, each pile thread is printed in colours according to the pattern to be formed, proper regard being paid in the process of printing to the length of warp which will be required to form the loop, and also for bending round the weft. Then they are put together in the warp in their proper order, and, as we have said, woven after the manner of Brussels carpet, but one printed thread serving for a number of coloured ones. This is a most economical method of producing figured carpets, but of necessity does not produce so serviceable an article as that which it imitates. There is no substance in the body, except what is known as the backing, and as this consists of stout linen, there is not the same elasticity as in the worsted body of Brussels carpet, and therefore not the same tendency to reduce wear and tear.

The structure of the Wilton carpets is similar to that of Brussels, but the pile is cut, or practically the difference is the same as that between cut and terry velvet.

127. The Varieties and Properties of Plushes.—We have now enumerated the principal kinds of plush or pile

which are made. There are many modifications of these in use, in the production of different kinds of fabric for different purposes, but these are modifications of minor details generally: the principle of structure is not affected by them. There are numbers of patent plushes, all claiming some advantage over others, but still, the improvement is usually in some trifling alteration of binding or distribution, or perhaps more frequently in the method of production, but the general principles we have referred to cannot be far departed from without impairing the structure of the cloth, or even if that is not actually done, there can be little advantage gained. One very economical method of making velvets, which has been attempted over and over again with varying degrees of success, has been within recent years brought to something like a state of perfection—namely, weaving two cloths together, and the pile passing from one to the other; they are then severed in such a manner as to leave a proper proportion of pile upon each cloth, thus dispensing with the use of wires, and consequently reducing the cost of production very materially. But even in this, the principle of structure of each cloth remains practically the same as if they were woven with wires; it is only a modification of the means by which the article is manufactured. With respect to the utility of pile fabrics, little need be said more than we have already pointed out. From the nature of the surface, as well as the structure of the body of the cloth, they must necessarily form very warm articles of clothing, the closeness of texture and the intermixing of the loose fibres of the pile all tending to assist in retaining warmth. They are also soft and pleasant to the touch, and altogether pleasing as articles of dress or furniture; one remarkable feature to which we have already referred being the richness of colour, and the variety of light and shade which they present, more especially when arranged in folds, the undulations placing the loose fibres in so many different positions to reflect the light, and this variety of reflections

giving richness and variety to the colour and lustre of the whole fabric.

In their wearing properties plushes are also very valuable, there being scarcely any fabric of the same weight which will prove more durable, so that they combine all the properties which go to make cloths valuable—richness and beauty with utility.

CHAPTER IX.

GENERAL COMPARISON OF THE DIFFERENT CLASSES AND STYLES OF FABRIC.

128. **The Considerations involved in the Structure of Fabrics.**—We have dealt pretty fully with the different principles of structure of fabrics and their ornamentation ; and it will perhaps be desirable now to examine a little more fully some of the considerations involved in their structure, to make a comparison of the different classes and styles of fabric, and also to deal with some forms of ornamentation which we have not touched upon, and the special method of their application.

We may first recapitulate generally some of the points discussed in the earlier chapters, so that we may take a more comprehensive view of the whole.

Dividing, for the moment, all fabrics into two distinct classes, without entering into their particular structure, we may say that the one is intended for useful and the other for ornamental purposes. Taking the purely useful, we have the question of strength before us, the necessity of the fabric being able to bear strain, or friction, or both ; then we have to regard it as an article of clothing, its power of retaining the warmth of the body, or of resisting climatic influences. In the first case one of two con-

siderations comes in; either we must have a strong, compact, well-formed thread, of which to form the cloth, or the threads must be so interlocked with each other as to make the whole fabric as it were one solid mass. If the threads are of such a nature that all the fibres of which they are composed are spun intimately together, forming a smooth-surfaced, even filament, then they will stand separate from each other in the fabric, and its entire strength will consist of the multiplication of so many units; and if the cloth is to bear a great strain, more especially if this strain is likely to be localised, either each individual thread must be very strong, or strength must be obtained by having a great number in a small space. The strength of individual threads may be obtained in two ways: either by having it constructed of fibres of great strength, or by having the fibres well twisted together. Combined with the strength of the thread, the order of interweaving of the two sets of threads of which the cloth is composed must be taken into account, and, as we have shown of ordinary fabrics, the plain cloth, or that in which the two sets of threads interweave alternately, is the strongest for the quantity of material which it contains (we are leaving gauze out of the question, as being an ornamental fabric). If the capacity of the fabric to bear strain is to be in one direction rather than another, as in the warp or weft, then that material must predominate, and we arrive at the class of cloth showing a rib in one direction or the other. We have here, then, the general considerations of strength immediately before us, and although we have spoken only of plain cloth, the remarks will apply equally to twilled or other fabrics, in which we have resorted to a different order of interweaving, either for the purpose of obtaining greater weight or for ornamentation.

In cloths formed of the kind of thread we have spoken of there will be openness of texture, and the size of the openings between the threads will be in the direct ratio to the diameters of the threads in a

cloth where warp and weft are equal in quantity. Thus, to obtain closeness we must increase the quantity of either warp or weft. To do that is to increase the weight. Now, if our cloth is to be a light one, and we wish it to be still of a close texture, we may obtain it to some extent by altering the structure of the thread. Instead of having a smooth, even thread, we may have a considerable amount of loose fibre on the surface; these loose fibres will help to cover the interstices, and in the process of finishing, if the fibres of one thread be made to interlock with those of other threads, the compactness of the fabric will be increased. But this is not all; the interlocking of fibres gives additional strength. Not only do the warp threads support each other, but the weft threads interlock with them, and the whole fabric becomes more compact, not merely as far as closeness of texture is concerned, but as regards tensile strength, and also the power to resist friction. Thus we have here a very intimate relation between the structure of the thread and the strength of the fabric, as well as its closeness of texture; so that it is evident the character of the thread is an item we cannot afford to ignore in determining the structure of the cloth.

Apart from the question of material or structure of thread, we must now consider how these conditions can be obtained in the structure of the cloth only. If we resort to twilling—that structure which most nearly approaches to plain cloth—we obtain in the first place greater closeness of texture than in an ordinary plain fabric, because of the necessity for introducing a greater number of threads, to compensate for the looser order of interweaving. We obtain also greater strength for the same reason, and also of course increased bulk. Then, again, this increase may be in the weft, in the warp, or both, according to the character of the twill we employ. If we take satin cloths—one form of twilling—we obtain all we require in strength and closeness of texture in one direction only—that is, by an increase of

either warp or weft, in number of ends or in thickness, more generally by the increase of ends. Our next alternative is a resort to double cloths, which gives us the means of increasing weight, strength, or closeness of texture to any degree. Then we have here, in the structure of the threads, and the structure of the fabric, in simple form, all that we require to enable us to make the cloth fulfil all the conditions of usefulness.

129. Ornamentation of Fabrics by the Use of Colour.—Now with respect to ornamental fabrics. As we have shown, we may ornament with colours, with patterns formed upon the fabric, or in the structure of the fabric itself. We will first turn our attention to the question of ornamenting with colours, not with a view to dealing with the theory of colour in general—that has been already done many times in works on decorative art, including, of course, textile fabrics, in a much more complete manner than could possibly be attempted here—but to consider it in its connection with structure of the fabric, and see what will affect or interfere with its use, and how far this interference may necessitate the ornamentation assuming some particular form or character.

It has been pointed out in a previous chapter that the ornamentation of plain cloth must be by the use of colour, or by the predominance of either warp or weft, so as to produce cords running the length of the piece or across it; but this predominance of one of the materials will also affect the use of colour. When weft and warp are equal in plain cloth, we may introduce coloured threads into either one or the other with a fair chance of their being visible on the surface. Then we may form either stripes or checks, just as we use coloured threads in the weft or warp, or both; and the variation in those threads, in both colour and quantity, will give us great scope for the display of ingenuity and taste. True, the patterns always run in straight lines, yet they may be made both pretty and effective by proper regard being

paid to variety of line and colour. But it is only when warp and weft are equal, or nearly equal, that we may use colour in both warp and weft at will. We will suppose, for example, that the warp is predominating very largely, that the number of ends per inch greatly exceeds the number of picks; then the weft will be completely hid, and whatever colour it might be it would not be seen on the surface of the cloth; so that in such a case we are precluded from using variety of colours of weft, and consequently, the cloth being plain in structure, we can only apply colour to form stripes running in the direction of the warp, seeing that the only coloured ends which can be visible must be in the warp. On the other hand, if we are making a corded cloth, with the cord formed in the warp, then the weft would predominate largely in quantity, though not necessarily in the thickness of the threads; but the closeness of the weft picks would completely cover the warp, so that whatever might be the colour of the warp, it would not be seen, at least not sufficiently to permit of a pattern of coloured ends being formed by it. So that whether the warp or weft predominate, we can only use colour in that portion of the fabric. Precisely the same rule will apply to twilled or satin cloths, and perhaps even in a more marked degree than in the majority of plain cloths. In either twill or satin cloths, where the warp or weft is brought much to the surface, it also predominates largely in actual quantity also; so that the other material is thrown absolutely to the back of the fabric, and is not seen at all on the face. Thus we can ornament only in the direction of the threads which are on the face, and we are therefore necessarily confined to stripes.

Although we cannot form anything but stripes by the use of colour in fabrics where either warp or weft predominates on the face, and when we confine ourselves to the material which forms the ground or body of the cloth, yet we are not precluded from the use of extra weft or warp to form checks. But of course the cloth will cease

to be purely plain, twill, or satin, as the case may be. We will take as an extreme instance a cloth, say such as a repp, in which the warp predominates very largely, and introduce coloured threads in the warp; these colours will stand out very prominently, because the modification usually produced by interweaving with the weft is not present here, the weft being so completely hid. Then if we wish to form a check upon this, our coloured weft must not interweave with the warp in the usual manner, or it will be lost, but it must be thrown to the surface of the cloth, and interweave with the warp threads only at intervals. In fact, it must form either a twill or satin with the weft predominating, and by this means and this only we may form our checks as distinctly as we please. If it is a cloth in which the weft forms the surface, then the coloured extra threads must be in the warp.

In forming figures upon such cloths as we are speaking of, the use of colour is most effective. Suppose the warp is a light colour and the weft a dark one, and that a figure is formed by bringing the weft to the surface, the warp preponderating on the surface all over the ground; in the ground the colour of the warp only will be seen, the weft being hid, and in the figure the weft only will be seen, so that the pattern will stand out very prominently. If the colours be properly suited to each other, so as to form an harmonious contrast, the effect will be most striking.

Then in using colour for the ornamentation of fabrics when the coloured threads form part of the groundwork of the cloth, it is evident we must take into account the structure of the fabric, and only use the colour in such manner as will be effective. When we are using extra colour or coloured threads for the sole purpose of ornamentation the conditions are quite different—whether we use them in the weft, in the warp, or in both—from those which exist when the coloured threads form the ground fabric; when they are extra threads we may treat them as we please, bring them to the surface in long

or short periods, or bind them into the cloth, so as to intermix the colour with the colour of the ground threads, and so modify their effect. In short, we employ them for decorative purposes only, and need to use proper discretion in their disposal, so as to produce the effect desired, with little or no regard to the structure of the ground fabric, except such as has been previously pointed out.

130. The Use of Threads of mixed Colours.—In speaking of coloured threads we generally mean threads which are one colour throughout, but we are not necessarily confined to coloured threads of this description in ornamenting fabrics. We may twist two differently coloured threads together, and so produce a parti-coloured one, known in the trade as “granderelle;” or we mix fibres of different colours together, in the preparation of the material for spinning, and so produce “mixture” yarn; or we may have the fibres of which the thread is to be composed printed in one of the intermediate stages of preparation, and so produce the “melange” yarn; or we may have the threads printed. From such fancy yarns as these we may obtain very pretty effects upon fabrics which may be perfectly plain in their structure; or if a pattern is formed in the fabric, it may be of the simplest kind. The whole effect may be a mixture, or melange. We may introduce the twisted, coloured, or printed threads into otherwise solid coloured fabrics, or coloured threads into mixture fabrics. These extra threads, as we may term them, may either form part of the ground cloth or interweave simply as ornamenting threads, according to the kind of effect to be produced, whether it is to be of a mild, tame character or a striking one. In fact, we have a wide field thrown open for the exercise of ingenuity in the use of these fancy threads. The use of “mixture” or “melange” threads generally is for the production of a tertiary coloured effect upon the fabric with very small patches of strong local colour; and if several striking colours are introduced into the mixture it does this in the most

effective manner. The intimate mixture of the fibres in the yarn will, when woven into the cloth, insure to the utmost the tertiary effect being procured, while on moderately close observation the local colours will assert themselves, and even at a distance will give a bright, sharp freshness to the whole.

In cloths where no specially striking effect is intended, the best means of ornamentation and of producing prettiest effects is by the use of "mixture" threads.

131. Fancy Yarns in Fabrics.—In addition to fancy yarns composed of differently coloured fibres, or by the twisting of differently coloured threads, many very good effects are obtained by twisting two threads together of the same or different colours, at different degrees of tension, so that one wraps loosely round the other—say, for instance, a thick thread twisting more or less loosely round a fine one—and presents to the eye a kind of crimped effect; this, when woven into the fabric, if judiciously used will be very pretty. Again, loops may be formed upon the thread by one thread running in loosely during the process of twisting while the other is held tight, or one thread may be given off at a regular rate of speed, while the other is varied in speed, so producing not only different thicknesses of thread, but, if the two threads are of different colours, different coloured effects. All these give us powers of ornamentation merely by their introduction into an ordinary fabric. We now come to the question of the ornamentation of fabrics in their structure, and we will consider it first apart from the question of utility.

132. Ornamentation of Fabrics in their Structure.—In plain cloths we can form patterns in one way only—namely, by the formation of ribs, which may run either lengthwise or crosswise in the piece; these ribs we may vary in size, or place at varying distances, but we have no further power of ornamentation. In ordinary twill cloths we have similar ribs running diagonally

across the fabric, which we may vary in size and distance apart, but unquestionably we obtain the best effects when we either combine these diagonal ribs with small figures, or simply run small figures in a diagonal direction. There is no field so wide for obtaining different patterns in the structure of the cloth as in the combination of diagonal lines and figures. The variety of lines, heavy and light, and the combination of forms give us a power of ornamentation which is not to be exceeded by any other method where we do not call in the aid of colour. There is no branch of the subject which should be more carefully studied by the textile designer, especially where his province is as much the designing of fabrics as of patterns.

Next we come to the formation of figures by the ground weft, warp, or both—that is, by the material which forms the ground fabric ceasing to interweave, and so forming pattern by the weft, or warp, or both, lying loosely on the surface. By this mode of figuring we can produce any variety of form in the figures, and, by proper regard to the order of binding or interweaving, ornament the fabric to any extent, the only limitation being a due regard for the structure of the fabric. Then we have figuring with extra material, which again gives us the power of introducing additional colours, as well as the formation of distinct patterns on the surface ; so that our power of forming patterns is extended beyond that when the figures are formed by the ground material alone, and if we combine the two methods we have a still further extended power. In fact, the extent and elaborateness of our designs are without limit, and may fairly be likened to the use of colour and brush. Figuring with double cloths may perhaps best be compared with the use of extra material, as we have not only a figure of one colour upon a ground of a totally different colour, each formed by different materials, but any amount of figuring may be introduced without affecting the structure of the cloth, and moreover, the

fabric is reversible and may be used on either side. The advantage of figuring with double cloth, apart from the question of utility, is that the figure is perfectly solid in colour, upon a ground equally solid.

Gauze, net, and lace are forms of ornamentation quite different from all other classes of fabric, and for lightness and elegance of fabric, as well as for the variety which may be introduced into the design, far exceed all others. Gauze is perhaps the most simple, and in the forms in which it is now generally made is probably the easiest of production; at any rate, it possesses one advantage over both the others—it can be combined with ordinary woven fabric, either for the purpose of varying the design, or for ornamenting a cloth of closer or heavier texture. The other two will give a greater degree of openness and lightness.

Plush ornamentation is peculiar to itself; it may be made to form simple figures, or the pattern may be in the plush itself. In what are commonly known as velvets—that is, where the pile is very short—the ornamentation is usually confined to the use of colour, in stripe or check form, or the formation of figures by the pile; but in what are commonly termed plushes, where the pile is longer, the ornamentation more generally takes the form of making the pattern in the plush itself, either by waving, crimping, or varying the length of the pile, or some such expedient. We have used the terms velvet and plush here in the popular sense, not with the intention of making a distinction between the two, for they may be taken as being practically synonymous, so far as the manufacture of such articles is concerned.

133. Ornamentation by different Tension of the Threads, etc.—In addition to the methods of ornamentation we have referred to, there are many others which can scarcely be called regular, but are the result of some freak or fancy on the part of the designer or manufacturer—such, for instance, as the introduction of slack or tight ends in the warp, either singly or in numbers.

Suppose we allow a single end at intervals to run into the cloth much slacker than the rest of the warp; it will crimp all along as the cloth is formed, and if it be a different colour from the body of the cloth, it will assert itself very strongly and produce quite a novel effect. Again, if a number of these threads have different degrees of tension, and of different colours, the effect will be still more novel. Another use of tight and slack ends is to form crimped stripes. Suppose one portion of the cloth is woven quite plain, and the rest twilled, or satin, the two running side by side in stripe form:—the twill or satin, if not very much more closely set in the reed, will permit much more weft being inserted than the plain; then if the warp threads come off separate beams, one for the satin and the other for the plain, and the latter is allowed to go in quite slack, the weft as it is beaten in will carry the plain cloth forward, while the satin portion is quite straight, and so cause regular crimps or waves in the plain portion. These crimps may be increased or decreased, made more or less prominent by varying the setting of the warp threads in the plain or satin portions, or by varying the tension at which the warp threads are held.

134. Utility combined with Ornament.—We may now consider the question of utility combined with ornamentation, or, in other words, in all the various forms of ornamentation with which we have dealt, examine into their effects upon the fabric, and see how far they will affect its utility. Beginning again with plain cloth, as we have shown, when warp and weft are equal, there is no ornamentation except by the use of colour; but we have a strong useful fabric, not heavy, except so far as the thickness of the threads of which it is composed makes it heavy, and not of a close or compact texture, owing to the order of interweaving of its threads, but yet strong and useful for the quantity of material which it contains. If we ornament it in its structure, it must be by the alteration of the relative quantities

and thickness of the warp and weft ; and in doing so we increase closeness of texture, generally also bulk and weight of fabric. By increased closeness we obtain necessarily increased strength ; for although each unit of strength, as represented by any single thread, may be less than in an ordinary plain cloth, the combination of these units will give greater strength to the whole. So that by ornamentation we increase usefulness both in wearing properties and in the power of retaining warmth as an article of clothing.

When we ornament by twilling, we again obtain practically the same results—namely, increased weight, strength, and closeness of texture. The order of interweaving of necessity produces these results, but in different degrees, by the different kinds of twilling ; so that it becomes necessary for the designer in making his pattern to consider thoroughly its effect upon the fabric, and the kind of fabric he desires to produce ; and the relative quantities of warp and weft must be carefully proportioned to the design of the twill.

When we come to figuring with the material which forms the ground fabric—that is, when the fabric is of a given structure, and a figure formed by the weft and warp ceasing to interweave, and one coming to the surface as loose material—whatever may be the structure of the ground cloth, the formation of the figure must in some degree detract from it. If the ground is plain, we shall have a firm texture, though perhaps somewhat open ; but when figure is formed, we have positively no texture, simply so much loose material ; in that case the usefulness of the fabric is decreased, and just in the ratio of the amount of figures introduced. If the figures be small and closely set together, the texture of the cloth as a whole will be looser ; if they be large, then it will give extreme looseness in the figured portion, and will not much affect the ground, which will be in proportionately large patches ; but the cloth will be very irregular in texture, and this of itself is a serious drawback. Then.

for useful purposes, the small figures, equally distributed, are preferable ; for if the texture be very much loosened, we may to some extent compensate for it by the introduction of more material, either in warp or weft, or both, and treating it somewhat as we should treat a twilled cloth. Whatever applies to figures upon plain cloth also applies equally to figures upon any other ground, when the figure is formed by loose material.

If our figures are formed upon the principle of diapers or damasks—that is, by the warp and weft merely changing places, and still preserving the same order of interweaving—then our figures may be as large or as frequent as we please, without in any degree impairing the utility of the fabric.

When we introduce extra materials for the formation of figures, we in no degree affect the ground cloth, either for better or worse ; it is merely applying so much colour to the surface, adding certainly to the bulk of the fabric at that point, but not necessarily increasing its usefulness, the extra material being in most cases simply laid loosely on the surface, so that it possesses no special wearing qualities, and will not add materially to the powers of the cloth for keeping warm. Of course we are speaking of the formation of spot figures by extra material. If the extra weft or warp be distributed over the whole area of the fabric, then it becomes a different thing ; especially if it be bound into the cloth at the back, for it will then form a kind of double cloth, and often really two distinct fabrics. Of course in such cases we add to the fabric in every way ; we increase bulk, strength, and closeness of texture, and have a better wearing and a warmer article, as well as one more ornamented. Double cloths should always be treated under two distinct heads—first, when one of the cloths forms merely a lining ; and second, where the two cloths exchange places to form patterns. The former may include all cloths where either two warps and two wefts, or where one warp and two wefts are used, if

one surface be different to the other in texture and in pattern, and where one is intended for the wearing surface and the other merely as a lining. The second should include all cloths which are reversible—that is, which are wearable on either side, or in which either side may be made the face—whether there are two distinct cloths, or merely two faces formed either by two wefts and one warp, or two warps and one weft. In the first class will be included all fabrics which have a fancy face and a plain back, and which for wearing purposes are extremely useful. The texture of the face is usually fine, and ornamented according to the purpose to which it is to be applied, possessing generally all the qualities of useful fabrics. The back is of a more or less plain character according to the weight to be obtained, or it may be governed by the pattern and texture of the face, so that they may bear a proper relation to each other, its chief purpose being to give weight, strength, and warmth. In producing heavy cloths, as those required for overcoats, this principle is absolutely necessary, because the proper weight and texture of cloth could not be obtained in a single cloth. If we obtained weight it would be at the cost of fineness, and fineness would be obtained at the cost of weight; but by the combination of two cloths, or two surfaces, we can comply with both requirements at once.

When the cloth is reversible, both fabrics or both sides of the same fabric are equal in quality and texture, though perhaps different in colour. Each surface may remain the same throughout, or they may exchange places. Their exchanging places is merely for the purpose of forming patterns; it will not affect the structure or utility of the fabric as a whole. If the fabric consist of two separate cloths these will exchange places bodily, each preserving its own individuality; they continue to weave weft with warp in each cloth as though no exchange had taken place. If it consist simply of two wefts and one warp, or two warps and

one weft, the wefts or the warps only exchange places ; but on whichever side of the fabric they are weaving, they still preserve the same order of interweaving weft with warp. In fact, it may be said to be a double diaper, or damask, inasmuch as weft and warp always bear the same relations to each other in their orders of interweaving, whichever may be uppermost, so that whether figured or plain, the utility of the fabric is not impaired in the slightest degree. With respect to gauze fabrics we need not say much as to their utility ; they are essentially fancy or ornamental cloths. Strength they may possess, but for warmth and general wear they are not specially suited, so that we need only regard them, except under exceptional circumstances, from a decorative point of view, and if we should have to consider them for purposes of utility, it will be in combination with other orders of working, and the conditions which apply to other fabrics will also apply to them.

Plushes are essentially useful fabrics, as well as heavy ones, and in ornamenting them we very rarely impair their utility, except in the slightest possible degree. The body of the cloth must at all times be a very strong, compact structure, so as to hold the pile with sufficient firmness ; and whatever ornamentation is introduced either with or in addition to the pile, or whatever is done with the pile, will not much impair the structure of the body. The wearing surface may be more or less affected, but that is not generally a serious matter, but the body of the cloth will never be much affected. This is equally true of both weft and warp pile.

When we ornament with coloured threads we do not affect the utility ; the structure is not altered. We determine the structure of the cloth to suit it for the purpose to which it is to be applied, and then vary the colours of the threads of which it is composed, so that we first say what the cloth shall be, and then how it shall be ornamented with colour ; and although we may have to consider the structure in applying the colour

yet the colour cannot affect the structure nor its utility as a fabric. If we ornament by varying the degrees of tension of the threads, then we do impair the structure, for any strain thrown upon the cloth will be thrown upon the threads which are tight, and as they are only a portion of the whole, they cannot be expected to bear as much strain without fracture as if the strain were equally distributed over the whole fabric. Consequently fabrics of this kind must be made for purely ornamental purposes, and never considered as articles of utility, unless the slack threads are very few indeed.

135. The Special Knowledge required in the Manufacture of Fabrics.—We may now understand the special knowledge required in the manufacture of textile fabrics, and upon what it is dependent. We have first to consider the nature of fabrics, and the uses to which they are to be applied. Having determined what we require, the character of the fibre from which the fabric is to be made, and the structure of the thread, we must next enter fully into the question of the structure of the cloth, considering it first from the useful point of view, then from the ornamental, or from a combination of the two. In any case thorough mastery of the different structures, of the various modes of ornamenting in the structure, and also of the effect of ornament upon structure, so as to know the extent to which utility will be impaired or increased by the particular method of ornamenting, is absolutely necessary. Given all this, along with knowledge of the mechanical operations of weaving and also of decorative art, and the designer possesses all the materials for the successful following of his vocation; he will only further require those qualities which are essential in every walk in life—energy, perseverance, and a right application of his industry and knowledge.

G L O S S A R Y.

Angle of Twill.—The angle which a twill forms with the weft or warp.

Backed Cloths.—Cloths having a back woven upon them which serves as a lining.

Beams.—Rollers upon which the warp threads are wound side by side before being put in the loom. There are also cloth beams upon which the cloth is wound as it is formed.

Binding in Cloths.—The securing together in the process of weaving two separate cloths, or extra material used for figuring or other purposes on an ordinary single cloth.

Bobbin-Net.—An open perforated fabric formed by a series of threads crossing and partially twisting round each other.

Checks.—Patterns which are usually formed by coloured threads crossing each other at right angles.

Chenille.—A thread having loose fibres projecting from it.

Choking the Shed.—When the warp threads are so numerous, or of so rough character that they will not pass through between each other, and separate readily into two portions between which the shuttle may pass.

Cockling.—When the cloth, instead of presenting a smooth, even surface, is irregular, some portions standing up in bubbles.

Cords.—Cloths with ribs which run longitudinally, or in the direction of the length of the fabric.

Corduroys.—Cords formed with cut pile.

Crammed Stripes.—Striped fabrics in which one portion contains more warp threads in a given space than another portion.

Cutting Plush.—Severing the threads which are to form the "pile" or surface of the fabric.

Damask.—A cloth said to be named from the city of Damascus, formerly made of silk, but now of worsted or linen chiefly.

Density of Pile.—The closeness with which the threads of velvet or plush are set together.

Diagonals.—Patterns arranged to run in a diagonal direction across the fabric.

Diaper.—A cloth similar to damask, but with the pattern of a “chequered” character.

Double Cloths.—Two separate fabrics woven and fastened together in the process of weaving.

Doups.—A special arrangement of healds used for gauze weaving, and so arranged that they may cause the warp threads to cross each other.

Elongated Twills.—Twill which do not run across the fabric at an angle of forty-five degrees.

Extra Warp or Weft Figures.—Figures formed upon a fabric by material which takes no part in the formation of the body of the cloth.

Figured Cloths.—Fabrics having a pattern formed upon them by the order of interweaving of the weft and warp of which they are composed.

Figured Twills.—Figures running diagonally across the fabric.

Floats.—Where the weft and warp of which a fabric is composed do not interweave with each other. Sometimes patterns are formed by “floats” only, and sometimes “floats” are formed accidentally in the process of weaving, and produce imperfection.

Flushing is sometimes used in the sense of “floats.”

Fraying.—One set of threads slipping upon the other, and so producing imperfections in the fabric.

Gauze.—A light perforated fabric in which the warp threads are made to twist more or less round each other.

Healds.—An arrangement for effecting the separation of the warp threads, so that the shuttle carrying the weft can be passed between them. The heald consists of a series of cords having an eye in the centre, and attached at each extremity to a flat piece of wood, called the “heald shaft,” the warp thread being passed through the eye of the heald. Whenever the heald shaft is raised or depressed the warp threads are also raised or depressed, and so the warp is separated into two portions for the shuttle to pass between.

Jacquard Machine.—An apparatus for separating the warp threads in a similar manner to healds but on a more extended scale, and consequently facilitating the production of elaborate patterns.

Lace.—An open perforated fabric produced by the threads of which it is composed being twisted together in such a manner as to form patterns.

Lappet Figuring.—Figures or patterns produced on a fabric by a warp thread being made to cross and recross on its surface by means of a “lappet frame.”

Madras Muslin, or sometimes called Indian Muslin.—A light fabric figured by the insertion of thick weft threads, which are cut away where there is to be no figure.

Net.—A fabric formed in a manner somewhat similar to lace, but having its perforation equal.

Pile.—The threads which issue from and form the surface of fabrics such as velvets.

Plain Cloth.—A fabric in which the warp and weft threads are placed at right angles to each other, and which interweave alternately.

Plush.—A fabric the surface of which is covered by short threads which issue from the body of the cloth.

Repps.—Fabrics ribbed across the piece.

Sham Plush.—An imitation of a plush fabric produced by using Chenille weft. Sometimes sham plushes are made by “raising”—that is, dragging—the fibres partly out of a cloth of ordinary loosely constructed fabrics.

Shed.—When the warp threads are separated for the shuttle to pass through.

Shuttle.—A small apparatus for carrying the weft, and which is passed to and fro through the warp.

Swivel Shuttles.—An arrangement of small shuttles for forming figures on a fabric, somewhat after the manner of embroidery.

Tabby.—A name commonly applied to plain cloth.

Twill.—A pattern running diagonally across the fabric.

Velvet.—A short or closely shorn plush.

Warp.—The threads which run lengthwise in a fabric.

Weft.—The threads which run crosswise in a fabric.

Yarn.—The threads of which a fabric is composed.

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